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Coffee Selection

Arabica coffee has been grown by Europeans in East Africa for about forty years; several types from various countries have been introduced and tried but, until recent years, little has been done to select the best trees for propagation. The careful work of recording, discussed in Gilbert's article (printed in this number), that has been carried out from the Coffee Research Station, Lyamungu, has thrown much light on the cropping of coffee. Gilbert has shown how great a variation there exists between the individual coffee bushes, not only in regard to the amount of their crop but also in the periodicity of their bearing; some individuals take a time to recover from the strain of a large crop, while others bear heavily year after year. If only all the trees on a plantation had yields equal to those of the best, coffee planting would be much more profitable than it is at present with the usual mixture of good and bad trees.

The importance of selection is obvious; its value has long been recognized in the husbandry of temperate countries, and the large increases that it may produce in the quality and yields of tropical crops, for example rubber, have revolutionized

estate practice. The pioneer selection work on coffee which, as in the case of so many tropical crops, was carried out in the Dutch East Indies, is reviewed in Van Hall's article in this number. Van Hall shows what progress has been made and what difficulties have been experienced; there are many lessons that we, in East Africa, can learn from the studies carried out in the East Indies.

Unfortunately, the process of coffee seed selection is a slow one. Not only is it necessary to obtain records over a series of years before the value of a tree may be correctly assessed but also the worth of its progeny must be tested, and this process will require more years of recording; for experience has shown that it is not possible to judge the value of a coffee bush from its first few crops—individuals which are very productive when young may soon lose their vigour. It has also been found in Java that the relative value of different types varies greatly from district to district. The same consideration most certainly applies to East Africa; for example, the Bourbon coffee, of which old trees continue to give such large yields on Kilimanjaro, has a very short productive life in Uganda.

Nor will the difficulties of selection be overcome by vegetative propagation, for the Dutch have found that many outstanding trees do not retain their desirable characteristics when they are grafted on to other root systems. In fact, the selection of stocks appears to be almost as important as that of the scions for many types, even those which are closely related, have proved to be incompatible when they are grafted together.

As there are difficulties in the improvement of coffee either by seed selection or by grafting, it has been the policy in the Dutch East Indies to study both methods; and planters there may now use selected coffees either in the form of clones or seedling families. A large amount of hybridization between the different species of coffee also has been performed, but up to the present the improved types obtained by selection inside a single species have usually proved to be of more value than the interspecific hybrids.

Most of the selection work in the Dutch East Indies has been in connexion with Robusta coffee (*Coffea canephora*) in its various forms. In this species the process of selection in East Africa is much facilitated by the fact that it grows wild in the forests near the main centres of cultivation, Bukoba and Uganda; in addition to all the wild trees, there are many large old specimens growing on African farms which have been cultivated for many years and which furnish very valuable material on which to start selection.

Although the home of *Coffea arabica*, in Western Abyssinia, is not far from East Africa, yet there is no authenticated record of its occurrence in the truly wild state in British territory. The Nandi coffee (*Coffea eugenioides*), which is widespread in the forests of East Africa, in some of its forms resembles Arabica coffee, but it gives such poor yields under cultivation that it is not an economic crop. It is possible that some of other wild coffees, for example those found in the south of Tanganyika Territory, may prove to be of commercial value.

There is usually marked variation between the individuals of a wild population of some species of coffee (for example, *Coffea canephora* and *C. excelsa*), and the same variability probably occurs in wild *Coffea arabica*; before starting selection it is advisable to obtain as wide a range of types as possible. Yet it appears that only a small proportion of the forms of Arabica coffee are in

cultivation; for the coffee in Central and South America—the majority of that in the world—is descended from a single plant, sent from Java to the Botanic Gardens, Amsterdam, in 1710, whose progeny was distributed to other countries in Europe and a few years later to the New World.

Most of our Arabica coffee has been grown in a succession of countries before reaching East Africa, so close to its original home; it is probable that many variations which have occurred, and which might have been useful here, have been eliminated. Therefore, while for the near future it may be anticipated that good results will be obtained by selection inside the varieties whose worth is proved, it may be hoped that more outstanding types, even better suited to East African conditions, may be raised from the seed of wild trees and that eventually they will be available for distribution.

Coffee selection was commenced many years ago in the Dutch East Indies, and Van Hall shows how the coffee-planting industry there is now reaping the benefit of the work in the production of larger crops and of improved quality in the coffee. Gilbert's paper describes the excellent start that has been made with the large-scale selection of Arabica coffee in East Africa, and there is every reason to expect that in time the results of coffee selection will be of equal value to these territories.

A.S.T.

"How to Make a Light Ladder," page 205 of November, 1938, issue.—The third paragraph, first sentence, should read—

"The following treats of a ladder 15 ft. long and 1 ft. 6 in. wide at the top and 2 ft. 6 in. wide at the bottom."

In the sixth paragraph, for "extra tightness" read "extra lightness".

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A European Smallholding

This is intended to be a matter-of-fact account of the first stages in the development of a smallholding. No didactic intention is either expressed or implied because the author, having had neither previous horticultural or agricultural experience, is only too conscious of the amateurishness of his efforts, and is of the opinion that much better results could have been obtained by one who had had such experience.

For good or ill I took over some 75 acres of land, of which about 20 acres were already fenced and let for grazing. So the problem for me was to find out how I could most profitably use the remaining 55 acres, and, while getting the maximum income from them, leave them as good, if not better, than when I took them. Of these 55 acres, 25 were mostly thick Kikuyu grass, 25 rough scrub, three wattle and two unreclaimed swamp. There was a rather dilapidated but adequate house on the land and a good water supply. The altitude was about 7,000 ft., and the value of the land, in, say, 50-acre blocks, about £10 per acre.

Having no predetermining tastes in agriculture and having had no previous experience, I was fortunately free to put myself completely under the guidance of the above limiting conditions. But before beginning the account of the actual farm work I would like to say that I spent much time, and being rather unskilled suffered much tribulation, over the keeping of accounts because, although I know that many of the best farmers may and do succeed without any accounts worth the name, they are now the exception, even among those born and bred to the life. It is now generally admitted that this aspect of a farmer's work is as important as any for the average man. In the summarized figures I have given it should be noted that the first year is one of fourteen months, from February to March inclusive, so that it includes two years' clearing, while the second planting comes within the second year. All the figures relate strictly to the farm and exclude expenditure on the house-building and repairs, because that is largely a question of taste, family and means.

I was extremely fortunate in that pyrethrum gave me a strong lead, and I would like here to put on record an expression of gratitude to the pioneers of this industry, which has done so much to help not only smallholders but all those farming at high altitudes.

In the first year I started on the job in March, and having no machinery and not sufficient space to justify its use, I was only able to get some ten acres hand dug and prepared for planting when the rains broke. But this work was done thoroughly; first the digging, then the grass being beaten out and burnt, then a good forking during which most of the remaining grass was taken out, and finally another hand cleaning during planting. It will be seen that the preparation of this land cost just over £5 per acre, and I don't think that such thorough preparation by hand from solid Kikuyu grass can be done for much less. I literally stood over the work, thus getting much more experience of the men and work than I should otherwise have done. The planting of the pyrethrum followed and, as splits were then expensive, I tried to economize with the result that I got many more misses than I liked. Furthermore, I had not learnt that misses should be filled in as soon as possible, otherwise, if they are left to the next season, it is almost impossible to get them established. Instead

I went on planting and clearing as rain gave opportunity, and by the end of the next long rains I had got 30 acres cleared and planted with about an 85 per cent stand.

Although I had decided to make pyrethrum my main string, it was soon obvious that even a smallholding must have some balance, as it were. Quite apart from the wisdom of not keeping all one's eggs in the same basket, experience as well as a little study soon teaches that, apart from certain special lines and special market conditions, growing one crop is neither good farming nor sound business. I therefore fenced off some six or eight acres for grazing and poultry—this with the idea of capturing the "home" market. A young family can consume a considerable quantity of milk and eggs and the first aim of a smallholder who realizes that he cannot make a large income is to aim rather at living cheaply and well than at showing great profits, particularly when, as here, local markets are narrow and transport is difficult. I therefore went to a sale of culls and bought £12 worth. For this sum I got seven animals, of which two were calves. The only cow I bought off my own inexperienced bat was a queen of course; but even that I sold at a profit, so I forgave myself. The others continued to supply the family with milk and butter and the farm with compost until, as mentioned later, I decided to give cattle up.

I had of course got a vegetable garden going soon after we arrived, and the bountiful yield from this, together with the offer of a small but good vegetable contract, turned my thoughts in this direction as a source of quick ready cash to help with the heavy labour bill. I therefore began reclaiming the marsh which I was warned would be useless owing to the heavy rains and the inadequate drainage. However, having borrowed a level and found there was a fall of six feet, I started. I could write much about these two acres which have taken so much of my thought and attention. One of my pleasures was to watch this soil being changed by careful cultivation from soggy waterlogged cakes of swamp land into sweet aerated humus which it was a pleasure to dribble through the hands. It was heavy going and I only got one acre cleared and dug ready for planting the first year. I planted it in equal parts with celery, strawberries and vegetables. The main vegetable garden was on the better drained upland.

Deciduous fruits, particularly apples, seemed to have promising prospects. I thought that these, which take so long to come to maturity, would not be so readily subject to the dangers of over-production as many other crops in Kenya. I had seen that certain kinds of apples appeared to do well in the near neighbourhood, but I never regarded this as anything but a minor and interesting side-line. I put in some two hundred trees, besides a few plums, etc.

The above activities, plus the house, garden, etc., gave me sufficient occupation for the first year.

The second year saw an extension of the pyrethrum area to some thirty-eight acres, in spite of the not too encouraging prospects. At its lowest, I could see a small profit, and I thought that any crop that seemed likely to show a profit of £5 an acre was worth persevering with, though this did not prevent me from keeping my eyes open for any other possibility. The cleaning of the last eight acres had not been so expensive as the previous thirty, as they were covered with scrub and the patches of Kikuyu grass were not so heavy. The cultivation costs

this year were light. I imagined that this was due to my keeping the hoes busy. Experience has taught me that it was due to the land being new and to lightish rains. The next year was to tell a very different story. This year's crop was light to average for this area, being almost exactly 700 lb. per acre.

The following is a summary of the first year's accounts:—

EXPENDITURE

CAPITAL	£	RECURRENT	£
Pyrethrum		*Pyrethrum*	
Clearing ..	148	Cultivation ..	35
Planting ..	15	Picking ..	10
Buildings	30	Drying ..	4
Tools ..	15	Tools, Apparatus	5
Plants ..	105		
Vegetables, etc.		*Vegetables, etc.*	
Clearing ..	8	Cultivation ..	7
Seeds ..	4	Seeds, Apparatus	3
Fruit			
Clearing ..	3	Orchard }	
Trees and Planting	17	Cattle } Labour	11
Cattle		Poultry }	
Stock ..	12	*Miscellaneous*	
Buildings–Fence	15	Labour ..	9
		Compost ..	5
		Transport ..	40
Poultry			
Stock ..	2		
Buildings, etc. ..	7		
Miscellaneous ..	20		
	£401		£129

REVENUE

	£
Pyrethrum	60
Celery	12
Strawberries	3
Flowers, etc.	2
Poultry	1
Cattle	5
Vegetables	8
Miscellaneous, Rent, etc.	24
	£115

The vegetable business expanded a little and promised better. Another acre of the marsh had been dug up. Celery had done well until heavy and very early rains inundated the last quarter of the crop. Strawberries were disappointing. Except in unusually favourable seasons this was obviously not the most suitable place for growing them. Poultry I fear got little attention, but it did help the house, and I raised a small breeding flock of Aylesbury ducks which I intended to use as opportunity offered.

The cattle were showing distinct signs of decay, so owing to my limited acreage, the lack of a bull, the difficulty of getting a decent milker who would do other jobs, and the expanding needs of pyrethrum and vegetables, I thought I could make better use of their place provided I could rectify the balance of the farm from outside sources at a reasonable cost. I required cheap milk, and dung for compost for the vegetables. I was able to make very satisfactory arrangements for milk with a neighbouring farm by which I got sufficient to supply the house with whole milk and butter and the poultry with skim. There was a certain amount of skim left over for sale to boys. By this means I got milk at a cheaper rate than that at which I had been producing it myself and the grazing ground was made available for other purposes. As for manure, I was able to buy this at 25 cents a bag, which works out at about Sh. 5/50 a ton. The number of fruit trees was increased by some three hundred this second year. Many of those planted the previous year had got away well and showed distinct promise.

The following is the financial statement for the second year:—

EXPENDITURE

CAPITAL	£	RECURRENT	£
Pyrethrum		*Pyrethrum*	
Clearing	25	Cultivation ..	50
Planting	28	Picking	47
Buildings ..	30	Drying	14
		Tools, Apparatus	15
Vegetables		*Vegetables*	
Clearing	8	Cultivation ..	35
		Seeds, Apparatus	21
Fruit			
Trees	30	Orchard, Cattle, Poultry ..	17
Miscellaneous ..	15	*Miscellaneous*	
		Labour	20
		Compost	11
		Transport ..	60
		Miscellaneous ..	4
	£128		£294

REVENUE

	£
Pyrethrum	290
Celery	30
Strawberries	15
Flowers, etc.	20
Poultry	1
Dairy	4
Vegetables	85
Miscellaneous	24
	£469

I had now reached my limit of expansion in pyrethrum, and this year could only squeeze in two or three more acres. It was a terribly wet year, and the cost of weeding tells its own tale of panic. Perhaps it would have paid to let things rip while the impossible weather lasted. I don't know. In any case I plugged away and spent over £3 per acre on cultivation that year—a heavy burden for any crop. In addition to the heavy rain and consequent heavy costs there was no flowering in this area between February and October. The crop only reached 600 lb. per acre. Fortunately for me the price was rising. The chief trouble appeared to be that the wet weather had allowed the "dabibi" weed to get such a hold that it was impossible to get rid of it, and a fair number of plants passed out through constant chivvying.

Vegetables went ahead this year. Under the heading "seeds" is included expenditure in buying to meet expanding orders, and cultivation costs include the clearing of a new vegetable garden. As a matter of fact, it was a poor year for growing; the rains were too heavy. Although I sold a little more celery, the increase was not in proportion to the increased planting. In spite of spraying, septoria blight was devastating. The strawberries were standing in water in places. Ducks about paid for themselves but not for the work entailed. I came to the conclusion that unless one is prepared to turn out thirty ducks a week it is not worth while. I also came to the conclusion that laying hens would pay better for less work, so I bought a pen of Rhode Island Reds.

The following costs in connexion with pyrethrum may be interesting:—

	SECOND YEAR	THIRD YEAR
	Per lb.	Per lb.
	Cents	*Cents*
Cultivation	4·48	10·38
Picking	4·45	6·17
Drying	1·21	1·76
Miscellaneous ..	1·25	1·80
TOTAL	11·39	20·11

The following are the figures for the third year:—

EXPENDITURE

CAPITAL	£	RECURRENT	£
Pyrethrum		*Pyrethrum*	
Clearing	17	Cultivation	118
Planting	2	Picking	70
Buildings	15	Drying	20
Tools, etc.	2	Tools, Apparatus	20
		Vegetables	
		Cultivation	62
		Seeds, Apparatus	35
		Orchard, Cattle, Poultry	13
		Miscellaneous	
		Labour	6
		Compost	7
		Transport	75
		Miscellaneous	12
	£36		£430

REVENUE

	£
Pyrethrum	605
Celery	34
Strawberries	1
Flowers	10
Poultry, Cattle	20
Vegetables	213
Miscellaneous	24
	£907

As with the other figures, including the pyrethrum costs, nothing is included for European management or capital charges, but on the other hand the house got much free in the way of fruit, vegetables, poultry and garden flowers. Friends provided a number of grown plum, peach and pear trees, which yielded fruit in the second year. We found these and easily grown berries of various kinds most helpful in our family budget, and we have still to reap such harvest as there may be from our main fruit orchard.

So ends a rather bare account of three years' pottering on a smallholding. The work has filled life with a strong interest and considerable amusement, while the profit has not been negligible. This next year the net profits, provided there is no war, can hardly fail to reach £800 from this holding of 55 acres, a result which I imagine could hardly be equalled in any other part of the world. I know well enough that this is mainly due to the boom conditions in the pyrethrum industry, and that it cannot last long, but even without those and even without pyrethrum at all, I can think of a dozen sources of profitable and interesting work on a smallholding, and moreover I feel convinced that a more experienced hand could make the job a more profitable one than I have done.

Selection within *Coffea arabica* in Tanganyika Territory

By S. M. GILBERT, *B.Sc. (London), N.D.A., Dip. Agric. (Wye), Chief Scientific Officer, Coffee Research and Experiment Station, Lyamungu*

I—THE PROBLEM

In drawing up the programme for the station in 1934 it was considered that, apart from influences of environment, which are great, there might be trees in the existing coffee populations on European estates and African holdings in the Territory which, owing to their genetic qualities, were particularly suited to certain conditions. The problem is to find such trees.

II—THE QUALITIES SOUGHT

On the production side economic studies, almost without exception, show yield to be one of the leading factors influencing the financial returns from a given area. As an illustration, Table I shows results from an investigation of over two hundred coffee estates in Puerto Rico.

TABLE I

IN COMPARATIVE UNITS

Yield	Income
6	—194
9	—79
10	148
12	760
20	886

East African coffees are classed as "milds" and, as such, command higher prices than types like "Brazils". Upkeep of the standard of quality is therefore very important.

What may be termed the "field characters" of the plant must also be studied. That is to say the form of branching, the root system, the flowering habit and similar characters should be suitable for the particular locality served. General hardiness and vigour may also be included under this heading.

III—METHOD

(*a*) *Yield.*—In connexion with field experiments it has been considered advisable to record individual tree yields in cherry on an extensive scale. At present some thirty blocks of contiguous trees, spread over all coffee districts, are being recorded. This in the aggregate now involves about 20,000 trees. At each picking a recorder from the station attends. As each tree is harvested the cherry is placed in a basket at the foot of the tree. Each tree has its own number label. The cherry is then weighed by the recorder on a portable spring balance, which is checked at frequent intervals by ordinary weights.

Until the complete technique of selection (completed early in 1938) was worked out it has been confined to these blocks. In some cases four years' records have been completed but a further two years would seem necessary. The periodicity of yield of *Coffea arabica* unfortunately appears to be very irregular, even between neighbouring trees, although biennial bearing is the most common. In this habit too, however, neighbouring trees may be out of step. The causes of this irregularity in bearing are not yet understood.

The average yield of cherry per tree is reputed to be about 1½ kilograms. The minimum standard for selection at present is 8.5 kg. of cherry, on the average, per annum. Trees, such as L 1 (see Table II), that show little variation in annual

yield are thought to be preferable, but all reaching the minimum on average are retained until the causes of yearly fluctuation in yield are more fully understood. These causes may be found to be easily controllable.

TABLE II

Year	Annual yield in kg.	†Equivalent mean yield : Cwt. per acre	Average weight of bean (grms.)	Percentages		
				"A"s	Bold	Length
1934	5·46	14·4	*	*	*	*
1935	12·82	33·8	*	*	*	*
1936	7·51	19·8	·187	87·96	18·02	Mixed
1937	12·75	33·6	·170	72·25	5·00	Short

*Not recorded

†In Tables II, III, IV and VII the figures in the third column give the equivalent number of cwt. of clean coffee per acre assuming a stand of 550 similar trees per acre and allowing for the actual out-turn of clean coffee obtained from the cherry of the recorded tree.

Before appearing in the list of potential selections the tree is examined in the field and if there are any discernible features of environment, such as extra spacing or shade, that may help the tree, due weight is given to the fact.

Table III gives a list of the best fifty-five potential selections to date.

TABLE III

55 Best Trees

Tree No.	Behaviour	Equivalent mean Yield : Cwt. per Acre	Type of Coffee
Regular Bearers			
R 3	* + + +	31	Bourbon
L 1	× + + +	24	,,
N 39	+ × + +	21	,,
N 197	+ + + ×	20	,,
N 71	+ + + +	19	,,
N 69	+ + + ×	16	,,
P 280	+ + + +	13	Java
P 313	+ + + ×	13	,,
F 839	+ + + +	12	Kents

TABLE III—(*Contd.*)

Tree No.	Behaviour	Equivalent mean Yield : Cwt. per Acre	Type of Coffee
Irregular Bearers			
R 13	* + — +	47	Bourbon
R 1	* + + ×	25	,,
R 11	* + × +	23	,,
N 20	+ — + —	23	,,
R 35	* + + ×	23	,,
R 4	* + × +	22	,,
N 50	+ + — +	21	,,
N 34	+ — + —	21	,,
N 219	+ — + —	21	,,
N 229	+ — + —	20	,,
N 181	+ + — +	19	,,
N 215	+ — + +	18	,,
N 5	+ — + ×	18	,,
N 119	+ — + ×	18	,,
N 10	+ — + —	18	,,
N 100	+ — + —	18	,,
N 182	+ — + —	18	,,
N 17	+ — + —	18	,,
N 53	+ × + —	17	,,
N 77	+ × + —	17	,,
N 176	+ — × ×	17	,,
I 56	+ — + —	17	Unknown cross
N 18	+ — + —	17	Bourbon
H 1	+ — + +	16	Unknown cross
H 61	+ — + +	16	,, ,,
N 81	+ + + —	16	Bourbon
H 133	+ — × +	16	Unknown cross
N 30	+ × + —	16	Bourbon
N 36	+ — + ×	16	,,
N 16	+ — + —	16	,,
N 29	+ — + —	16	,,
N 76	+ — + —	16	,,
N 106	+ — + —	16	,,
N 213	+ — + —	16	,,
I 428	+ × + —	15	Unknown cross
N 198	+ — + —	15	Bourbon
N 211	+ — + —	15	,,
I 235	+ — × —	15	Unknown cross
J 49	+ — + +	14	,, ,,
J 104	+ + — +	13	,, ,,
P 80	+ + + —	13	Java
P 147	+ + — +	13	,,
E 59	— + × ×	12	Blue Mountain
Selected for Bean Weight			
B 160	× + × +	13	Bourbon
H 66	+ + + ×	12	Unknown cross
H 68	+ × + —	12	,, ,,

+ Above 6 kg. — Below 3 kg.
× Between 3 and 6 kg. * Not recorded

TABLE IV

Year	Annual yield in kg.	Equivalent mean yield: Cwt. per acre	Average weight of bean (grms.)	Percentages		
				"A"s	Bold	Length
1935	30·64	69·7	*	*	*	*
1936	1·49	3·4	*	*	*	*
1937	33·30	75·8	·151	57·75	4·25	Short

*Not recorded

Trees may be selected on yield alone in view of their possible use as stocks or because good bean characters are not important for the particular market in view, as for example Tree R 13 (Table III).

(*b*) *Quality.*—This term covers a number of characters of the bean. Coffee being a beverage it is obvious that "cup" quality should be of first importance. However, it appears that there are no well defined standards of comparison, and classification in this respect may depend to some extent on the idiosyncrasy of the liquorer. Moreover, the liquorer himself takes other characters of the bean into account in his valuation of the quality of a particular sample, as is shown by Table V, a form of assessment commonly used in East Africa.

A further point calling for study is that clean coffee is "sized" for width—called "grading" in the trade—presumably because larger and more uniform sizes obtain a better price. It must be remembered in this respect that the screens for any particular grade are not standardized; that is, Grade A at one place and time may be of a size different from Grade A elsewhere.

Whilst therefore the points awarded for quality under "Roast" and "Liquor" present certain difficulties in precise assessment, those under "raw" can be accurately measured by the selector. In consequence, work at the station is at present confined to the examination of certain physical characters, such as volume, weight and appearance. Nevertheless, samples from potential selections do have their "cup" qualities examined by a competent liquorer.

Much detailed work has been necessary to evolve a simple technique for describing the characters of the several thousand beans of any one tree and for calculating the number necessary to take as a sample that is adequate from the statistical point of view. As a result it is now known that a random sample of 350 beans from the *whole crop* of one tree is sufficient. Weight is so positively correlated with volume ($r = +·992$ average for six trees examined) that the latter measurement is unnecessary, besides being very troublesome to calculate accurately. As, however, density of bean may be found to be correlated with quality a general idea as to volume is obtained by screening for length, width and boldness.

In all their characters neighbouring trees may have differences that are statistically significant, frequently highly significant. This may of course be due to either environment or constitution, or both. Only field tests using clonal material will settle this point.

Producers may sell their coffee in parchment or they may have it cleaned and graded before sale. From all selections samples are therefore examined for "out-turn". It is clear from the examples that in this respect trees differ and also that the individual tree varies from year to year. The season has a marked effect.

Table VI gives the out-turn of sixteen trees for 1937. It may first be noted that yield is not directly correlated with

TABLE V

COFFEE REPORT

MARK REFERENCE No. .....

OUT-TURN No.....

RAW					ROAST				LIQUOR		
Size	Colour	Evenness of Drying	Weight	Defectives	Type	Make	Centre Cut	Evenness	Acidity	Body	Flavour
4	4	2	2	2	Brilliant 3	Hard 2	White 2	2	Very pointed 6	Full .. 4	3
3	3	1	1	1	Bright 2	Mixed 1	Irregular 1	1	Strong .. 4	Medium 2	2
2	2	—	0	0	Dull .. 1	Soft .. 0	Brownish 0	0	Medium .. 2	Light .. 1	1
1	1	—	—	—	—	—	—	—	Light .. 1	Harsh 0	—
0	½	—	—	—	—	—	—	—	None .. 0	—	—
	0										
Very Good					Very Good				Very Good		
Good					Good				Good		
Fair					Fair				Fair		
Poor to Fair					Poor to Fair				Poor to Fair		
Poor					Poor				Poor		
Remarks :					Remarks :				Remarks :		

GENERAL QUALITY

Very Good .. ..
Good .. ..
Fair .. ..
Poor to Fair .. ..
Poor .. ..

REMARKS : *Signature*.....

Date .....

TABLE VI

DETAILS	B 160	D 628	L 1	N 39	N 71	R 3	Q 90	Q 221	J 49	J 104	J 106	R 13	H 1	H 61	H 133	R 2
PART I ON WHOLE CROP																
Yield (in Kg.) 1937.. ..	10·39	11·86	12·75	6·37	6·10	14·60	7·80	9·05	12·05	11·30	6·45	35·30	9·35	6·20	7·40	11·45
Percentage outturns—																
Parchment to cherry ..	19·3	18·6	*	*	*	*	17·0	19·3	*	*	*	*	*	*	*	*
Clean to parchment ..	80·9	83·1	04·1	81·3	80·7	*	83·3	81·5	*	*	*	*	*	*	*	*
Clean to cherry	15·6	15·5	*	*	*	*	14·1	15·7	*	*	*	*	*	*	*	*
Peaberry to clean ..	16·6	11·7	2·7	9·1	7·5	*	10·7	7·3	*	*	*	*	*	*	*	*
PART II 400 BEANS RANDOM SAMPLE																
Average weight per bean (in grammes) ..	·150	·190	·170	·173	·150	·156	·194	·148	·154	·149	·147	·151	·193	·184	·169	·162
Percentages																
Width—																
Screen 8 ..	74·25	92·75	72·25	78·50	44·50	54·25	84·25	51·75	65·50	58·00	68·25	57·75	91·25	88·25	75·75	57·50
Screen 6A ..	13·50	4·25	17·50	11·00	14·00	14·00	10·25	23·50	14·75	15·25	12·25	18·75	4·50	6·00	12·00	15·75
Screen 4 ..	7·25	2·25	6·00	5·50	14·75	14·00	3·25	13·50	10·00	14·50	8·00	9·00	3·00	3·75	7·75	14·25
Remainder ..	5·00	0·75	4·25	5·00	26·75	17·75	2·25	11·25	9·75	12·25	11·50	14·50	1·25	2·00	4·50	12·50
Bulkiness—																
Large ..	9·00	19·50	5·00	5·25	9·75	15·00	16·00	1·50	2·75	3·50	2·75	4·25	13·75	12·50	12·00	7·25
Medium ..	8·00	14·75	4·00	3·25	6·25	8·75	10·25	5·75	3·50	2·75	3·75	7·00	14·75	15·75	10·50	7·00
Small ..	17·00	28·50	18·25	15·25	10·50	21·75	22·00	11·00	12·50	8·75	7·00	17·00	23·00	17·25	21·50	14·75
Remainder ..	66·00	37·25	72·75	76·25	73·50	54·50	51·75	81·75	81·25	85·00	86·50	71·75	48·50	54·50	56·00	71·00
Length—																
Long ..	1·75	32·25	24·75	53·50	28·00	9·00	66·75	10·00	18·25	11·50	14·25	5·50	35·00	36·25	18·75	15·00
Short ..	98·25	67·75	75·25	46·50	72·00	91·00	33·25	90·00	81·75	88·50	85·75	94·50	65·00	63·75	81·25	85·00

*Whole crop used for seed

weight (and therefore, size) of bean. Tree H 1, with a mean bean weight of .193 gramme, has yielded fifty per cent more than J 106 which has a poor bean.

The initial advantage of bigger cherry yield possessed by Q 221 over Q 90 is reinforced by the fact that the percentage of parchment obtained from its cherry is 19.3 compared with 17.0. There is also an appreciable difference in the proportion of clean coffee to cherry. On a basis of 500 trees per acre these factors would give a yield of nearly 140 lb. more clean coffee per acre from Q 221 than from Q 90. On the other hand, the bean characters of Q 90, weight, width, boldness and length, are superior. What immediately affects the planter is that in the saleroom a smaller quantity of a heavy bold bean may fetch more than a larger consignment that is inferior in those characters. The important point, however, at this stage is that selection of the type of tree required and its propagation by the rooting of cuttings will tend to even up the irregularities in out-turn and bean characters now found in seedling coffee.

It must not be forgotten, however, that the above characters may almost certainly be affected by cultural operations. Good trees require good conditions. For example, in 1937 in all our experiments sulphate of ammonia applied at the end of the abnormally heavy rains prevented the serious falling-off in out-turn shown by plots not so treated.

Trees such as H 66 (Table VII) may be provisionally selected on bean qualities alone, as it may be possible to increase their yield economically by cultural methods. Further, these trees may prove desirable as providers of scion material for working on vigorous stocks with poor bean characters, such as R 3.

TABLE VII

Year	Annual yield in kg.	Equivalent mean yield: Cwt. per acre	Av. weight of bean (grms.)	Percentages		
				"A"s	Bold	Length
Tree H 66						
1934 ..	6·38	12·0	*	*	*	*
1935 ..	9·03	16·9	·216	86·90	21·50	Long
1936 ..	7·24	13·6	·219	92·97	37·92	Long
1937 ..	3·92	7·3	·192	88·75	47·00	Mixed
Tree R 3						
1935 ..	13·40	30·5	*	*	*	*
1936 ..	15·09	34·3	·146	38·11	7·45	Short
1937 ..	14·60	33·2	·156	54·25	15·00	Short

*Not recorded

(c) *Field Characters.*—It may so happen that trees that do not thrive on the single-stem system of pruning will do so on one of the forms of multiple stem. On steep hillsides anti-erosion measures may call for an upright type of growth instead of a spreading one. Certain types of growth may be more conducive to pests and diseases. Many other points will occur to the practical man. All these must be taken into account in final selection.

Other characters which have not yet been studied but which may be of considerable importance are time of flowering, flushing habit and ability to withstand wind and drought.

IV—Conclusion

As a result of these investigations the Lyamungu Station is in a position to enlarge its practical selection work and invites producers, in their own interests, to co-operate by drawing attention to likely trees. Even before trees are finally selected, which will take from five to six years, both seed and suckers from such trees should be propagated in order that much valuable time may possibly be saved. Such material is hardly likely to give progeny inferior, under the same conditions, to that now used by producers.

Seasonal Conditions and the Planting Season with Special Reference to Kilifi and Malindi Districts of Kenya

By N. HUMPHREY, *Agricultural Officer, Kenya*

I—SEASONAL CONDITIONS

These notes refer primarily to Kilifi and Malindi, but I consider the general discussion has a wider application to all the Coast Districts of Kenya, excluding Voi.

The long rains on the Coast are generally recognized as very irregular in their incidence and quantity. Some years back, when I examined the figures available, I found considerable difficulty in coming to any definite conclusions that might be helpful, but almost invariably the June rainfall was less than the May, and it was possible to conclude that the end of May and the first week in June marked the end of main rainfall for the season. After that time one could expect lighter rain in June and July, which gradually tailed off.

It appears quite definite that the key month of the season is May. Given good rain well distributed throughout that month, then it is fairly safe to expect a medium to good season with little or no danger of serious crop failures. The rainfall in the following months, of course, will have its effect on plant growth, incidence of disease and yield, but that effect appears generally to be limited to some change in yield, good or bad, which is insufficient to alter the main trend of the season towards plenty or scarcity. Even in the exceptional year of 1936, when June rains were extremely heavy, for practical purposes this rain was too late to be effective. Following from this conclusion, one can recognize two distinct types of season, which may be called early and late, though it is doubtful whether those descriptions are strictly accurate.

(i) In the "early" seasons in Kilifi good rain may be experienced through March and April, but the main fall ceases early in May. These are the seasons in which crop failures may occur, especially in the back country, since much of this rain never penetrates further than the coastal ridge from the Shimba Hills, through Chonyi, Sokoke and Arubuko.

(ii) In the "late" seasons, only light rains fall before the end of April and early May. May itself has a heavy record distributed throughout the month. As previously stated, such a season is likely to be a successful one generally, because even the back country gets the benefit of these rains.

Naturally, there is no clean-cut division between these two types, and there are the exceptional years in which the rains may be a complete failure, but the recognition of the two types does give some guide to expectations. Thus, in recent years, 1930, 1933, 1936 and 1937 are of the early type. Serious crop failures occurred in 1930, 1933 and 1937; 1936 was mitigated by an exceptional June, but crops were all below average in all the dry areas. 1931, 1932, 1935 and 1938 are of the "late" type; 1934 belongs to the same group but was exceptional in the continuance for months of wet, dull weather.

II—THE PLANTING SEASON

It is sometimes thought that it should be possible to lay down with great precision the optimum time for planting the various crops. But it is not easy to be as definite as one might hope. For simplicity

it is necessary to consider the different areas separately.

A—All Dry Areas

It is essential that in these areas early preparation of the land should be carried out. It has been noticed recently in Kilifi and Duruma as well as in former years that unless food is short the local natives are extremely backward in preparing their *shambas,* and, unless constantly pressed, are rarely ready as soon as they should be. *Shambas* should be prepared well in advance, for possible planting in late March or early April.

Planting of all crops, food or cash, should be done as soon as practicable after the rains break. In a good year this gives a chance of getting a bumper crop; in a bad year it may mean the difference between an average crop and nothing. Planting must be done quickly. One day in these areas will often be much better than the next, and the waste of one or two good planting days can make all the difference in a lean year. This emphasizes further the need for *shambas* to be ready.

Given early preparation, early planting and the new drought-resistant crops, there should be a decrease in the number of food shortages in the future. It is not possible to overcome the true famine year, but it is possible greatly to lessen these food shortages. Similarly with cotton, the same methods in most of these areas would ensure far fewer failures.

Although these notes are mainly concerned with the long rains, it should be remembered that in the dry areas the short rains are often the best for food crops, and the same principles of early preparation and early planting apply, with the proviso that planting is likely towards the end of October or early in November.

Although less quickly affected than some of the dry areas, most of the Sabakhi Valley belongs to this type and the same remarks apply. Early planting should not be limited to the cereals, but it is essential that it should include cotton if that crop is to give adequate returns to the grower.

B—Coastal Area—Mombasa to Malindi

It is generally dangerous to plant food crops in this area much before the middle of April. Only local experience can say when it is worth risking an earlier date. It is probably preferable to delay the new *mtama* even later, but it is satisfactory to have the bulk of the cereals planted before the end of April if possible. April planting of cotton can sometimes be done but it is definitely risky. Cotton is best planted when the rains have really broken, i.e. at the end of April and early May. It is essential to plant the bulk then in case the season is "early", but planting can be continued throughout May, and in a "late" season this may be necessary. In the latter case some damage may be done by flooding, so that replanting becomes necessary, but this is a minor trouble. Cotton in this area should be finished by the end of the first week in June.

C—Southern Kilifi Reserve (excluding Dry Areas)

In this area the rainfall tends probably to be rather heavier than along the Coast. Soils are also heavier and more affected by heavy rain. Food crops are generally planted early with satisfactory results, but here, as elsewhere, it is customary for natives to plant whenever opportunity occurs. It is difficult to object to this practice in spite of its disadvantages from the pest point of view, owing to the impossibility of knowing for certain in any

season which will be the best time to plant.

Cotton is more susceptible to the weather here than in the areas already considered. If it can be planted early enough to have made a good start before the heavy rain breaks it will come through satisfactorily. Planting during the heavy rain gives poor results, but should be done immediately the rain eases off and before the land begins to dry.

Generally speaking, heavy rain may be expected at the end of April or early May, and planting should start as soon as it is possible thereafter. Heavy rain in late May, as in the present year, may do some damage, but at the same time it allows for replanting and extension once the land becomes suitable for planting again. The two dangers are:—

(*a*) Planting whilst heavy rain is continuous;

(*b*) delay in planting after the rains have eased off.

D—Digo Coast

Cotton-growing in this area has poor chances until some improvement in drainage and soil fertility becomes possible. Early plantings suffer frequently from waterlogging and later plantings from drought. An exceptional year like 1938 offers possibilities for June planting, but in many years such plantings are doomed to failure, and the objections to late crops on other grounds apply with equal force to this area.

Conclusion

From the above remarks it will be realized that the essential factor is for the land to be ready before the planting season opens, and that when the time to plant comes the operation should be carried out as quickly as possible. This is an essential in any endeavour to lessen food-crop failures in the dry areas. It is equally important for cotton if the crop is to make a good start.

It should always be remembered that early planting of cotton offers the greatest chance for obtaining good crops of first quality seed cotton. Such damage as may occur in exceptional years can be remedied by replanting. Late cotton in a good season does not give the same return as early, and may dishearten growers in future seasons owing to their dissatisfaction with the results of their labours. In early rain seasons, late cotton tends either to be a complete failure or to rely on the short rains for its development, in which case a poor, low quality crop may be expected. In such years, which are frequent, no chance exists for replanting the crop. Early planting, early harvesting and early uprooting are needed for good cotton crops under Coast conditions.

Agricultural Education in Uganda

By E. G. STAPLES, *M.A., Dip. Agric., Senior Agricultural Officer (Education), Uganda*

I—INTRODUCTION

In the broadest sense, agricultural education may be said to have begun in Uganda with the foundation of a Department of Agriculture in 1911. With the introduction of "economic" crops, such as cotton and coffee, it was necessary to instruct the people of the country in the proper way of growing them. This was done, partly by officers on tour and partly on the various plantations maintained by the Department. African instructors in cotton and coffee growing were also appointed and after a short course of training toured various parts of the country for this purpose.

With the appointment of the first Director of Education in Uganda in 1925 and the establishment of an Education Department, an officer of the Department of Agriculture was appointed to take charge of agricultural education and to act as liaison officer between the two departments. His first work was to organize and conduct a course of instruction in agriculture in connexion with the newly formed Makerere College. He was also concerned with helping to give an "agricultural bias" to the education given in the schools of the country, which had lately been reorganized.

Work on these lines expanded rapidly, and the need for increased staff for this work in the Department of Agriculture was soon felt. In 1930 two Agricultural Officers (Education) were appointed to assist with the work, and in that year two centres for agricultural education were opened at the Department of Agriculture's two main field experiment stations, at Bukalasa in the Buganda Province and at Serere in the Eastern Province. These were at first occupied in giving short courses in agriculture, nature study and school gardening to elementary and secondary schoolmasters. In 1932, in addition to the teachers' classes, short courses were started for African instructors working under the Department of Agriculture or under one of the Native Administrations. In 1933 short courses in agriculture for chiefs were started at these two centres. Courses for chiefs, instructors and schoolmasters have since been held every year and the available accommodation at Bukalasa and Serere is now usually full throughout the year.

A further addition to the staff was made in 1930, when a third Agricultural Officer (Education) was appointed for lecturing to the Makerere College agricultural class.

In 1933 courses lasting for two years were started at Serere and Bukalasa for young men intending to become farmers; a number of "teaching" smallholdings being established at each of these centres for this purpose. In the same year the Uganda Government started to give annual grants to two of the Missions for a similar purpose, and farm schools for training young men as farmers were opened by the Church Missionary Society at Namutamba in the Buganda Province, and by the Verona Fathers' Mission at Gulu, in the Northern Province. A rather similar smallholdings training centre was started by the Lango Native Administration at Ngetta in the Northern Province in 1937.

II—Vocational Training in Agriculture

With a small European staff and an African cultivating population of about three millions, it is evident that the training of an adequate African staff is an essential prerequisite to getting across to the peasants the necessary propaganda and education to raise their standard of cultivation and to enable them to obtain a better living from the land, while at the same time safeguarding the soil from loss of fertility and preventing all forms of soil erosion.

This African staff consists of a senior division and a junior division. Candidates for the senior African staff must have successfully completed the five years' course in agriculture in connexion with Makerere College.

(1) *The Makerere Course in Agriculture*

This started as a three years' course in 1925; it was lengthened to five years in 1933. Candidates must have passed the Makerere College entrance examination before they are allowed to enter the course. As will be seen below, tuition is given during the first two years by the staff of Makerere College, during the next three years by the staff of the Department of Agriculture.

The course is organized as follows:—

First Year (at Makerere College).—Continuation of general education.

Second Year (at Makerere College).—During this year a grounding is given in general elementary science, including physics, chemistry and biology.

Third Year.—During this year the students continue to reside at Makerere College, but tuition is given mainly by members of the staff of the Department of Agriculture.

The following is the scope of the work during this year:—

Agriculture—
- (i) Crop Production,
- (ii) Animal Husbandry,
- (iii) Experimental Agriculture.

Agricultural Chemistry.

Agricultural Botany.

Agricultural Pests and Diseases.

Veterinary Science (lectures given by an officer of the Veterinary Department).

Elementary Surveying; Book-keeping (tuition by members of the staff of Makerere College).

During this year nearly all classes are held at the Department of Agriculture's Laboratories or on the attached Plantation. Excursions are arranged during this year to places of agricultural interest, such as coffee and tea estates, sugar estates and factories, tobacco factories, etc.

Fourth and Fifth Years.—These years correspond to the time spent by an English agricultural student on a good farm. A complete year is spent at each of the Department of Agriculture's field experiment stations at Serere and Bukalasa. The training during these years is entirely practical and students are given practice in all of the various departments of work at these centres, including the organization and management of labour, field experiments, and the management of smallholdings. They are also required to learn how to carry out in a proper manner all of the operations needed on a farm, such as ploughing, anti-erosion measures, spacing and planting of the various crops, the handling and management of coffee trees, practical methods for the control of pests, the making of farmyard manure and compost, the laying of cement drying-floors, farm carpentry, and the care of cattle. From time to time they accompany

agricultural officers on tour and gain experience in various lines of work, such as village surveys, etc. A course of lectures throughout these two years is designed to show the practical application of their previous lectures and laboratory work.

The majority of the Uganda students who have passed successfully through the Makerere course have been taken into the African Civil Service as African Agricultural Assistants in the Department of Agriculture.

Although the bulk of the students attending this course come from various parts of Uganda, a few Kenya students have already taken the course. These normally do the last two years of the course under the Kenya Department of Agriculture, but in cases where a knowledge of cotton is required the fourth year is taken in Uganda.

(2) *Short Courses for Agricultural Instructors*

The majority of the agricultural instructors who form the junior African staff of the Department of Agriculture have attended one or more short courses of instruction at Bukalasa or Serere. These courses are usually of one or two months' duration, and the instruction given is of a simple, practical nature. It includes such things as the maintenance of soil fertility, the construction of bunds and other methods for the prevention of soil erosion, the use and value of crop rotation, the making and use of farmyard manure, laying out and measuring plots, the recognition of cotton pests, and the writing of reports.

(3) *The Agricultural Training of the African Farmer*

So far we have considered the indirect ways of approach, by means of the African staff, both senior and junior, to our main subject—the African cultivator.

To a limited extent, the direct instruction of peasant cultivators has always gone on as far as the staff available would allow. As stated in an earlier paragraph, however, an experiment in the training of young men as farmers was started at Bukalasa and Serere in 1933.

At each centre small farms were established and staffed with pupils who had come for a two years' course in practical farming. At Bukalasa one of the holdings and at Serere all the holdings are run as "mixed farms" with cattle. The areas under the different crops and the rotations followed are based as closely as possible on the common practice found on family holdings in the respective districts. All the work of the holdings, except the herding of the cattle, is done by the pupils. In the afternoons they are given talks on the work and planning of a small farm and are taught how to keep simple accounts. They are taught the reasons for an orderly lay-out of the ground, the meaning of soil fertility and how to maintain it by the application of kraal manure and by grass fallows, how to make a covered cattle kraal, how to make and store kraal manure, how to make a farm sledge, how to prevent soil erosion by bunding and other means; in fact, how to maintain themselves permanently on a settled farm instead of practising shifting cultivation. At the end of the course the pupils are given help and encouragement in starting on a small farm themselves. In some cases a small capital loan is provided for them by the local Native Administration.

The experiment is due to run for a period of ten years before the suitability or otherwise of this method of training is decided definitely. There are indications that the best material for training consists of cultivators who are already settled

on the land. Young men who have passed through an elementary school usually have their minds rather firmly set on obtaining paid employment and are somewhat disinclined to settle down to the life of a farmer.

It is quite possible that instruction and training on the cultivators' own holdings will prove more satisfactory in the long run than comparatively long courses at centralized training centres.

III—Short Courses for Chiefs

Since 1933 short courses in agriculture for chiefs have been held at Bukalasa and Serere. A slightly different system is followed at each centre. At Bukalasa a comparatively small number of chiefs have been given a three months' course, while at Serere all the chiefs of a district attend, in batches, for a very short course lasting only a fortnight, during which some single point of good husbandry is taught, such as better ploughing or practical means for preventing soil erosion. It is hoped by these means to stimulate the interest of the chiefs in agricultural improvements and, through them, to influence the mass of peasant cultivators.

IV—A "Rural Bias" for the Schools

When the school system in Uganda was organized in 1925 it was decided, in view of the fact that Uganda is a country depending upon agriculture for its wealth, to include nature study, agriculture and school gardening in the curricula of all the elementary and most of the other schools. This meant that the teachers in these schools had to learn how to teach these subjects. The trained staff necessary for this work was not available at the normal schools where these teachers go for their training. It was decided therefore to organize short courses for schoolmasters at Bukalasa and Serere. The first of these courses was held in 1930 and they have been held every year since then. Every schoolmaster has been required to attend and to qualify at one of these courses, either during his ordinary training or subsequently.

As far as time has allowed the educational staff of the Department has followed up this work by visits to the schools, has assisted with the lay-out of plots and gardens, and has given advice upon the teaching of these subjects.

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The Comparative Feeding Values of Grass When Fed Green, as Hay, and as Silage

By M. H. FRENCH, *M.A., Ph.D., Veterinary Department, Mpwapwa, Tanganyika Territory*

European settlers in East Africa are frequently faced with the question of how to get the most out of any given crop. This is particularly so for grass. Grass, unless it is correctly managed, quickly becomes fibrous and mature and of less feeding value to stock. In most of East Africa it is even more difficult to get the maximum value out of grass because the climate is such that growth only takes place during a short period. With the rains green grass is everywhere abundant and it is quite impossible for any farmer to keep his land grazed down and under control with the small number of stock that is the maximum his land is capable of carrying at the end of the dry season. What should the farmer do? If he buys cattle he is buying at a time when no one wants to sell, and if he stocks his farm so that he keeps his grass down he will have to get rid of surplus stock when the dry season comes along and no one wants to buy animals.

If maximum returns are to be obtained from grassland, the farmer must graze down a certain proportion of it in rotation and conserve the fodder from the areas he cannot control by grazing. In order to determine what is the best way of conserving grass in East Africa the following comparative trials were made.

The object of the experiment was to compare the compositions and feeding values of a crop of mixed grasses, (*a*) fresh, (*b*) made into hay, and (*c*) made into pit silage. Previous work has demonstrated that better quality products are obtained if grass is cut when in the flowering stage than if it is allowed to become mature and set seed. In this work the grass was cut at 11 weeks old for silage and hay, and between the 10th and 12th weeks for determining the feeding value of the fresh green grass. The feeding value of the hay was ascertained after four months' storage in the fodder shed and the silage digestibility studies were made after it had been in the pit five months. The same adult male sheep were used in all the nutritional studies, so that variations in digestibility due to individual differences were not introduced.

The compositions of the green grass and of the hay and silage resulting from it are set out in Table I.

TABLE I

COMPOSITION OF FRESH GRASS AND THE RESULTING SILAGE AND HAY (DRY MATTER BASIS)

	Green Grass	Silage	Hay
Crude Protein	8·41	9·55	8·64
Ether Extract	3·02	2·62	2·51
N-free Extract ..	46·45	36·64	45·03
Crude Fibre	30·98	36·33	34·16
Total Ash	11·14	14·86	9·66
SiO_2	5·67	8·83	4·40
SiO_2-free Ash	5·47	6·03	5·26

The green grass used in this experiment was about two feet long and consisted largely of Star grass (*Cynodon plectostachyum*). At the time of cutting the majority of the plants possessed inflorescences from which the anthers had emerged and no seeds had yet been formed. The composition is normal for

grass in East Africa which has reached the stage of maturity suitable for hay-making.

The hay and silage differ considerably in composition from the green grass from which they were made. It is perhaps advisable to give a brief résumé of the changes taking place in the grass during ensilage and hay-making so that the significance of these differences may be understood better.

Ensilage is always attended by losses of nutrients due to (*a*) respiration of plant tissues, (*b*) enzymatic activity of the plant juices, and (*c*) bacterial fermentations. These biochemical changes cause a considerable consumption of carbohydrates, with the result that the N-free extractives are decreased and the other constituents proportionately increased. Incomplete oxidation of these carbohydrates, owing to the limitation of air during ensilage, results in the formation of organic acids which increase the relative amounts of the ether extract. Proteolytic hydrolysis reduces the amount of the true protein fraction. In addition, the plant juices that drain away remove some of the soluble protein cleavage products, soluble carbohydrates, and mineral constituents. A diminution of the crude fibre percentage results from the bacterial conversion of celluloses into lower carbohydrates. It is the balance of these biochemical changes and the drainage losses which determine the composition of the resulting silage. Usually an increase of ether extract and crude fibre constituents with a decrease in the proportions of the other fractions characterize the changes during ensilage. In the present grass silage, however, proteolytic breakdown has not been so marked, and the crude protein content is actually above that for the green crop. Similarly the production of organic acids has not caused an increase in the ether-soluble material. The increase in mineral matter is due to the soil contamination inevitable in a small-scale pit experiment. A marked decrease of carbohydrates is observed, due to inefficient consolidation of the grass in the pit.

Hay-making is also attended by losses of nutrients from the original material. Cell respiration and enzyme activities continue for some time after the grass is cut and this reduces the carbohydrates. In the tropics the hot sun causes the plants to die off quicker than in temperate regions, and the loss of carbohydrates is thus reduced. Carting and handling the hay cause a loss of the more tender and drier leaves, but in this study care was taken to reduce this loss as far as possible. Certain fermentative changes also occur in the stack and cause a further small loss of carbohydrates. This sample of hay contained slightly more protein and fibre than the green grass from which it was made but less of N-free extractives.

The digestibility trials ran smoothly and no disturbances occurred. The grass silage when removed from the pit was olive-green in colour and possessed a pleasant smell. It did not correspond either with "green fruity" or "acid brown" silage, but seemed to be intermediate in type.

The average digestibility coefficients of the three foodstuffs are given in Table II.

TABLE II

DIGESTIBILITY COEFFICIENTS OF SILAGE AND HAY AND OF THE GREEN GRASS FROM WHICH THEY WERE PREPARED

	Green Grass	Silage	Hay
Crude Protein ..	59·79	48·58	45·14
Ether Extract ..	56·24	65·68	57·39
N-free Extract ..	56·01	51·54	48·26
Crude Fibre	56·09	61·59	54·13
Ash	42·50	83·01	37·55
Dry Matter	54·79	61·30	49·19
Organic Matter	56·35	57·42	50·44

Compared with the fresh grass the silage protein was less well digested. This is in general agreement with other observations that heating, such as occurs in a silage pit, causes a depression of protein digestibility. The ether-soluble matter of the silage was better digested than that in the fresh grass, probably owing to its organic acid content. The bacterial fermentation in the silage pit had rendered the silage fibre more digestible than that of the green grass.

Between the fresh grass and the dried hay there is even more difference in digestibility and all the constituents show lower digestibility coefficients in the hay. This agrees with the more extensive recent studies of Watson, Ferguson and Horton in England (*J. Agric. Sci.*, 27, 224, 1937).

TABLE III

DIGESTIBLE NUTRIENTS AND STARCH EQUIVALENT VALUES OF FRESH GRASS, AND THE HAY AND SILAGE MADE FROM IT

	PER 100 PARTS DRY MATTER		
	Fresh Grass	Silage*	Hay
Digestible Crude Protein	4·99	4·84	3·90
Digestible Ether Extract	1·57	1·78	1·44
Digestible N-free Extract	25·08	19·68	21·73
Digestible Crude Fibre	18·47	23·31	18·49
Digestible Organic Matter	50·11	49·61	45·56
Starch Equivalent ..	33·27	28·99	26·83
Nutritive Ratio..	1:9	1:10	1:11

*Calculated on a 5 per cent SiO_2 content to bring it into line with the fresh grass and hay.

If the nutritive values of these three foods are calculated the figures given in Table III are obtained.

The figures indicate that conservation of green grass either as hay or silage is attended by loss of nutrients, and that the dry matter of these two preserved foods is of less feeding value than the dry matter of the original grass. Although the experiments described above deal only with grass composed largely of *Cynodon plectostachyum* the same results can be expected when other grass species are conserved. Unpublished results recently obtained indicate similar loss of nutrients when the following grasses are converted into hay: *Chloris gayana, Cenchrus ciliaris* and *Andropogon caricosus*. The ensilage of *Panicum maximum* was also found to be attended by loss of nutrients.

Many farmers consider the ensilage of grass only when rain spoils the cut grass for hay production. It cannot be too strongly emphasized that a farmer must decide beforehand whether he is going to make hay or silage from his grass. Grass that has started to dry off will not make the best quality silage because the dry crop cannot be sufficiently consolidated in the pit. Large losses of carbohydrate material then occur and the resulting silage will often be mouldy and unpalatable. For ensilage, grass must be succulent and must also be filled and trampled into the pit before it has a chance to dry. Grass which has been cut for hay but is then spoilt by washing with heavy rains cannot be expected to yield high quality silage. If the leaching by rain has spoilt the crop for hay-making, it has ruined it just as much for silage production. Grass that has been spoilt in this way is better dragged off the field and later dried for use as bedding rather than used for silage.

However, grass which has been only slightly washed by rain may be used, as was proved a few years ago when a crop of mixed grasses was cut for making into hay but heavy rains prevented it being cured quickly. Some of this rain-soaked grass was ensiled and, though the silage produced was not of such good quality as that reported upon above, its dry matter had the same feeding value as hay made from the same crop of grass in dry weather. This supports the result of this study, where the dry matter of silage, made from grass which had not been washed by rain after cutting, had a higher feeding value than that of the corresponding hay.

Summary

The conservation of green grass either as silage or hay results in a loss of nutrient matter. The dry matters of these two foods are of less nutritive value than the dry matter of the original grass. The feeding value of silage is at least as high as that of hay, and may be even higher.

A farmer wishing to conserve grass can make either silage or hay and get very similar amounts of nutrients. Labour costs and climatic considerations will determine which method is used; but it may be stressed that silage has the vitamin-containing succulence of green foods and so possesses added value for the dry-season feeding of certain types of stock.

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Communal Grain Stores in Nyasaland

By E. LAWRENCE, *Agricultural Officer, Nyasaland*

The following is a brief account of a scheme for communal grain storage which was tried during 1931 and 1932 on the Lower River. Conditions in the two districts of Lower Shire and Chikwawa are peculiar in that the most common grain crop is millet, either Pennisetum or Sorghum or both, and that owing to depredations of rats and insects and to the excessive manufacture and consumption of beer one year's crop seldom lasts until the following year's harvest.

There is a yearly period of grain shortage therefore commencing about December and lasting until the early Pennisetum crop is harvested, about February. This period varies of course from year to year but is seldom shorter than two and a half months and often longer; during it the people live on sweet potatoes and wild grass seeds.

After the particularly poor season of 1929-30 the hunger period commenced earlier in the year than usual, and the writer suggested that some form of control in the storage and conservation of foodstuffs was necessary. The scheme proposed involved eventually the construction in every village of a communal grain store to be under the direct charge of the village headman and to be filled with the individual contributions of the villagers. The stores would be fumigated periodically, under personal supervision of the Agricultural Officer, who would also be responsible, at least until the headmen were *au fait* with the method of filling the stores and of recording the contents.

Methods of storing grain on the Lower River are very primitive and the loss every year is heavy. The native cannot be altogether blamed for wishing to sell as much grain as possible at harvest time and for making the rest into beer. Unfortunately the Indian traders take full advantage of this, buying cheap grain at harvest time and re-selling to the native when the food shortage commences.

During 1931 seven grain stores were built, five on the Port Herald Experimental Station and two in villages. They were all copied from a type suggested by the Tanganyika Department of Agriculture and consisted of a cylindrical mudded container standing on a thickly mudded platform at least 4 ft. from the ground. In the original stores the top, the weakest part, consisted of a layer of loose sand 2 in. thick placed on matting supported by cross bamboos, but it was found that this was not sufficiently air-tight. Eventually the top was mudded in and a small manhole was cut in the side of the store for filling purposes. The whole structure was surmounted by a roof of thick thatch. Rat-stops were put on the uprights of the platform. The only materials required for the grain stores were poles, grass, bamboos, mud and fibre; any native could find all of these in the bush and the roughest of village carpenters could make the manhole. Each store held 5 to 6 tons of grain.

The first village grain store was built in April, 1931, at Makoko Village, and the description of its filling and emptying, given in the Annual Report of the Department of Agriculture, 1931, page 23, is quoted in full:—

> "All materials were carried in and all work was done by voluntary unpaid labour. After completion the store was

left to dry out thoroughly. A final plastering was given with a mixture of wood ash and cow dung. This mixture dries with a hard smooth finish, leaving no cracks. Towards the end of July the store was filled. Some anxiety was felt over the possibility of the development of mould in the grain during storage. Some of the grain, it was thought, might be unripe or damp when brought in, and to obviate the danger the grain was passed slowly along a trough made of a bent sheet of corrugated iron, a fire being kept underneath. Care was taken not to overheat the grain and directly it was thoroughly warm it was weighed and emptied into the store. Filling continued for two whole days and was completed on the morning of the third day. The grain was immediately fumigated with carbon bisulphide. The cubic content of the store was 124 cu. ft., and the dosage employed was at the rate of 8 lb. to every 1,000 cu. ft. of enclosed air space. A shallow tin standing on top of the grain held the fumigant, and when it had been placed in position the top was closed with a 2½ in. layer of fine sand on matting. The grass roof was placed over all.

"There were 114 contributions of grain to the store and the total weight of grain stored was 3,842 lb. Of this total there were 3,488 lb. of *mapira* (sorghum) stored loose, 141 lb. of mixed *machewere* and *mapira* in one sack, and 213 lb. of *machewere* in two sacks. It will be noted that the average contribution was about 30 lb. Such small contributions are not likely to be of great use in the hungry season, but this is the trial year for the stores and it is certain that next year contributors will be more numerous and individual contributions larger. Many contributors stated that they intended to use their grain for planting next season. Each one received a dated slip with his name, village and weight of grain. Each entry was made in triplicate and one copy of names and weights was held by the village headman Makoko.

"The store was visited regularly once a month, the grain being fumigated at each visit. Early in November it was found that the top of loose sand was not sufficiently airtight to exclude all insects. The whole top was immediately mudded in with the exception of a small trapdoor, and the grain refumigated. Another inspection a week later showed that the store was now quite airtight.

"Emptying took place on December 14 and 16. The seed was in excellent condition and the natives appeared to be pleased with the result. Germination was good, apparently quite unimpaired by the fumigation the seed had undergone. Village Headman Makoko has asked for two more stores for next year."

The following account from the same source is given of the stores on the Experimental Station, Port Herald:—

"Of the stores on the Experimental Station one was filled with *mapira* in September, fumigated, closed and left for a month, when it was opened and the grain examined. It was found to be free of weevil and moth, was refumigated and closed again. It was finally opened and the grain taken out for use late in December. Weevil and moth were present, but in small number. The grain was scarcely damaged and had lost practically no weight at all. A second store was filled with maize (shelled) early in October, fumigated and sealed. The top was not quite finished when it was filled and

the maize was slightly weevil-damaged before it could be treated with carbon bisulphide. It was examined again in November, when the grain was found to be free from insect attack.

"A third store was filled in October with maize in the cob, the sheathing leaves still intact. This store was built in the same way as the others, with the exception of the floor, which, made of inter-crossed split bamboos, was not mudded. A slow smoky fire was kept underneath. This maize was examined in December and was entirely free from insect attack. It should be noted, however, that the variety placed in this store is suspected of being immune to weevil attack; until the ordinary native maize has been successfully stored in this way nothing conclusive can be stated." (In any case, even native maize is known to keep well if the sheathing leaves are not removed.)

During the early part of 1932 there was every sign that the scheme would prove popular. Village Headman Makoko asked for a second grain store in his village, and rapidly collected the necessary materials. Native authorities Chimombo and Chipwembe and village headman Sabao all collected materials and began building grain stores in their villages. Early in May a very bad epidemic of smallpox broke out on the Lower River and all movement of natives and all travelling was stopped by the medical authorities. On June 23rd, just as the ban was lifted, the writer went on leave, and in his absence the scheme was abandoned.

In the two years it was shown that millet and maize grain can be stored satisfactorily in mud *nkokwes* and that natives can be induced to appreciate the value of communal *nkokwes* sufficiently to build them for themselves and to use them. The cost of fumigation was very small, and in the scheme outlined above was borne by Government.

It was stated at the beginning of this account that there is a seasonal food shortage on the Lower River and for this reason the scheme was particularly attractive to the people. In most other districts in Nyasaland there is not this imperative need for grain conservation nor is the popular grain used millet, but maize, which stands storage much better. Nevertheless, for other reasons, improved methods of storage are desirable. Grain stores all over the country are poorly built and are neither rat- nor insect-proof; a very large part of the grain crop is lost every year through bad storage. It is probable that a smaller type of grain store suitable for a family rather than a village will appeal more to natives in districts other than the Lower River.

Plant Diseases Spread by Bugs

By G. B. WALLACE, *B.Sc. (Agric.), Ph.D. (Edin.), Plant Pathologist, Department of Agriculture, Tanganyika Territory*

Many plant diseases of fungus, bacterial or virus origin are spread by insects. The present notes are concerned with problems of some common diseases caused by a group of yeast-like fungi that are spread by bugs of the sub-order Hepteroptera. These fungi are confined to the fruit and more usually to the seeds.

The disease has different names in different crops. The symptoms as found in cotton, coffee and legumes are briefly described below.

In Internal disease of cotton bolls the fungus spores are introduced by stainer bugs in the course of feeding; the spores germinate and the fungus mycelium develops rapidly in the young lint. The latter becomes dry and brittle, and develops a characteristic yellow or brown colour. The seeds may or may not be attacked. The cells in the mycelium are each capable of producing new spores; these are freed when the cell walls break down, and can be taken up when next a bug introduces its proboscis to feed on that part.

Coffee is attacked in the same way, the fungus being spread by the coffee bug Antestia. Only the seeds have been found affected. Coffee Bean disease has been described in leaflets of the East African Departments of Agriculture. The injury may be light or severe, depending upon the degree of ripeness of the beans when attacked. The affected part or parts of the bean dry up, shrink, and darken. An early attack results in the bean tissue being more or less completely destroyed, and only a shrivelled seed coat may remain. This is a frequent source of floats in the fermentaation tanks. In the drying frames the disease may be recognized by thin brown cracks on the outside of the parchment, and brown discoloration on the inside, quite apart from injury to the bean.

The disease in legumes is known as Yeast Spot. Seeds of legumes when lightly attacked show a flattened or slightly sunken area on the seed coat and this is separated from the rather shrunken infected part of the cotyledon. The infected part of the latter shows up fairly clearly in a cross section owing to its whiter and more starchy appearance; its lower boundary is marked by a grey-brown line—actually caused by air pockets in the tissue. A heavily infected legume seed becomes dry, shrivelled and dark. It is of interest that some beans which have been kept dry and free from insects for over eight years have been examined and found to show the spores of the fungus just as clearly as when the beans were first found infected.

In Table I a list has been compiled of the available records (mostly from the *Review of Applied Mycology*) of "Stigmatomycosis" or bug-carried diseases in East Africa and elsewhere. This list illustrates several important points: (1) the widely separated families in which susceptible species have been recorded; (2) the wide geographical distribution of the disease in crops such as cotton and legumes, and the restricted distribution in others such as coffee; (3) the considerable number of wild host plants—herbs, shrubs and trees. Such susceptible indigenous plants frequently serve as reservoirs for the parasites (both bug and fungus) outside the actual growing season of particular crops.

The number of known host plants is steadily increasing; for example, a new record in the list is a species of tree Acacia. It will therefore be realized that the absence of any plant name from the list does not necessarily imply resistance.

Five fungi of three genera are known to be bug-carried parasites. To avoid an extra column, *Nematospora nagpuri* is not included in the table; it was recorded from cotton in India in 1930.

For an account of four of the fungi concerned reference should be made to Nowell's "Diseases of Crop Plants in the Lesser Antilles." A more complete account is that by Ashby, S. F., and Nowell, W.: "The Fungi of Stigmatomycosis," in *Annals of Botany,* XL, No. 157, Jan. 1926, pp. 68–83, plates 4 and 5.

Intensive damage to the seed of a susceptible crop may be expected given the following conditions:—

(1) A reservoir of the fungus, which is to be found in seed remaining on the crop plants from the previous season (e.g. coffee) or in volunteer plants from the previous season (e.g. cotton) or in wild hosts.

(2) The presence of the insect vector in numbers; the following are genera of bugs in which one or more species are recorded vectors in different countries: *Antestia, Callidea, Dysdercus, Leptoglossus, Nezara, Odontopus, Phthia.*

(3) The crop at a susceptible stage of growth—chiefly while the fruits are young—when infected bugs are present in numbers.

Control of the disease can only be effected if one or more of the above conditions can be adequately modified. For example, if cotton can be planted sufficiently early its crop may be well matured before the insect vectors (*Dysdercus* of several species, *Nezara,* etc.) are in large numbers. If the amount of infective material can be kept down, the bugs will have less opportunity to pick up and transmit spores of the fungi. This implies elimination of volunteer plants after an annual crop and of old fruit on a perennial crop, and so far as possible destruction of indigenous host plants. Susceptible cover crops in a crop such as coffee, if found to harbour the crop pest, could be rendered harmless if cut down before they set their fruit. A difficulty sometimes exists in the fact that some bugs can fly over a long distance in a matter of days; for example, in South Africa marked individuals of *Dysdercus fasciatus* are recorded to have been captured within a fortnight after release at places $3\frac{1}{2}$ to $9\frac{1}{2}$ miles distant and on various sides, the wind being light throughout (see Progress Reports from Experiment Stations, Season 1936-37, Emp. Cott. Gr. Corp., 1936). There are, however, occasions when the insect vector can be controlled; such a case is that of Antestia in coffee. The fungus itself cannot be directly attacked as its entire life history is spent under cover, either within the fruit or seed or in an inactive condition in the insect.

There are cases where control is extremely difficult, e.g. among legumes, but the measures outlined above will indicate the lines along which some control may be effected in most crops.

TABLE I

LIST OF HOST PLANTS AND DISTRIBUTION OF NEMATOSPORA SPECIES AND RELATED FUNGI (REVISED TO 1937)

HOST PLANT		*Nematospora Gossypii* A. & N.	*Nematospora Coryli* Pegl.	*Spermophthora Gossypii* A. & N.	*Kremothecium Cymbalariæ* Borzi
Family and Species	Common Name				
ASCLEPIADACEÆ :					
Ascelepias curassavica	False ipecacuanha	W. Indies	W. Indies		
BETULACEÆ :					
Corylus avellana	Hazel		Italy		
CONVOLVULACEÆ :					
Ipomœa batatus	Sweet potato		U.S.A.		
CUCURBITACEÆ :					
Momordica charantia	Coolie pepper or carilla fruit		W. Indies		
EUPHORBIACEÆ :					
Ricinus communis	Castor		W. Indies		
Jatropha urens			W. Indies		
GRAMINEÆ :					
Zea mays	Maize		Italy		
JUGLANDACEÆ :					
Carya pecan	Pecan		U.S.A.		
LEGUMINOSÆ :					
Acacia sp.			Tan. Ter.		
Bauhinia galpini			S. Africa		
Cajanus cajan	Pigeon pea		Tan. Ter.		
Canavalia gladiata	Sword bean		W. Indies		
Cassia spp. (herbac.)			W. Indies		
Centrosema plumieri		B. Congo	B. Congo		
Crotalaria juncea	Sunn hemp		W. Indies		
Crotalaria retusa			W. Indies		
Dolichos lablab	Bonavist bean		U.S.A.		
			W. Indies		
			Tan. Ter.		
Glycine max	Soy bean	B. Congo	B. Congo		
		S. Africa	S. Africa		
Indigofera spp.			W. Indies		
Phaseolus acutifolius	Tepary bean		Tan. Ter.		
„ *aureus* (*radiatus*)	Green gram		Tan. Ter.		
„ *lunatus*	Lima bean	B. Congo	B. Congo	B. Congo	
			Ceylon		
			U.S.A.		
			W. Indies		
			Tan. Ter.		
„ *mungo*	Black gram	S. Africa	S. Africa		
„ *vulgaris*	Runner bean	S. Africa	S. Africa		
			U.S.A.		
			W. Indies		
			Tan. Ter.		
„ spp.		*Nem.* sp.	in Burma		
Tephrosia vogelii	"Fish poison"		Tan. Ter.		
„ spp.			W. Indies		
Vigna unguiculata	Cowpea		W. Indies	W. Indies	
			Tan. Ter.		
			U.S.A.		
Vigna sp.		B. Congo	B. Congo		
			Brazil		
			Tan. Ter.		
MALVACEÆ :					
Gossypium spp.	Cotton	W. Indies	W. Indies	W. Indies	W. Indies
		Burma	Burma	Bt. Gui.	
		S. Nigeria	S. Rhod.		
		Uganda			
		Nyasaland			
		Tan. Ter.			
		Kenya			
		N. Rhod.	N. Rhod.		
		S. Africa	S. Africa		
		P.E.A.	P.E.A.		
		Brazil	Brazil		
		Domin. R.			
Hibiscus cannabinus		Uganda			
„ *esculentus*	Okra	Uganda			
„ sp.		Brazil	Brazil		
Sida sp.		Brazil	Brazil		
PUNICACEÆ :					
Punica granatum	Pomegranate		U.S.A.		

TABLE I (*Contd.*)

LIST OF HOST PLANTS AND DISTRIBUTION OF NEMATOSPORA SPECIES AND RELATED FUNGI (REVISED TO 1937)

HOST PLANT		*Nematospora Gossypii* A. & N.	*Nematospora Coryli* Pegl.	*Spermophthora Gossypii* A. & N.	*Kremothecium Cymbalariæ* Borzi
Family and Species	Common Name				
RUBIACEÆ :					
Coffea arabica	Arabica coffee	Tan. Ter. Kenya	Tan. Ter. Kenya Uganda B. Congo		
Coffea robusta	Robusta coffee	Uganda			
RUTACEÆ :					
Citrus aurantium	Sour orange	U.S.A.	U.S.A.		
„ *limonia*	Lemon	..	U.S.A.		
„ *maxima*	Grape fruit	..	U.S.A.		
„ *nobilis*	Tangerine	U.S.A.	U.S.A.		
„ *nobilis* var. *unshiu*	Satsuma	..	U.S.A.		
„ *sinensis*	Sweet orange	..	U.S.A. W. Indies Tan. Ter.		
„ spp.		..	Philipp. China Japan		
SCROPHULARIACEÆ :					
Linaria cymbalaria		..	Italy		
SOLANACEÆ :					
Capsicum annuum	Red pepper	..	U.S.A.		
Datura metel		W. Indies			
Lycopersicum esculentum	Tomato	U.S.A.	U.S.A. W. Indies Mexico Cuba	W. Indies	W. Indies
STERCULIACEÆ :					
Sterculia platinifolia		S. Africa			
UMBELLIFERÆ :					
Cachrys lævigata		..	France		

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Some Aspects of Soil Conservation

BASED ON OBSERVATIONS IN THE CENTRAL AND NORTH KAVIRONDO NATIVE RESERVES

By A. W. THOMPSON, *Assistant Agricultural Officer, Kenya*

The main factors affecting the extent of water erosion on unoccupied land may be classified as follows:—

(*a*) Rainfall, particularly maximum precipitation during storms.

(*b*) Degree of slope.

(*c*) Amount and type of soil cover.

(*d*) Nature of the soil.

Of these, the first two may be said to be for all practical purposes beyond human control; both (*c*) and (*d*), however, are susceptible of variation, and in fact as soon as land comes under what is usually known as "beneficial occupation" are immediately subject to deterioration. With the advent of human occupation and its concomitants, agriculture and the keeping of stock, there enters a fifth factor, which by virtue of its effect on the pre-existing conditions is of major importance. This factor—

(*e*) Density of population,

is closely related to the system of land tenure and of agricultural practice of the natives of any district, and there are indications that it controls them to a large extent. With the more obvious benefits of civilization, freedom from intertribal raids, better nutrition and living conditions due to more varied food and cash crops, decreased mortality among human beings and stock as the result of the medical and veterinary services, all helping towards a rapid increase of the population, there exists necessarily a state of flux, but in general it appears that the greater the density of the population the more highly developed is the system of land tenure. That is, the more widely the idea of the private ownership of land is accepted.

It is the purpose of these notes to discuss some of the problems of soil conservation in native reserves, mainly in relation to this factor. Naturally there can be no hard and fast classification of population density, and there must be important differences due to climate, soil and topography between districts of the same density of population, but it may be sufficient if the following three arbitrary divisions are made:—

(1) Sparse population, up to 150 per square mile.

(2) Moderate population, 150 to 300 per square mile.

(3) Dense population, over 300 per square mile.

(1) *Sparsely Populated Districts.*—The inhabitants are usually pastoral rather than agricultural. The percentage of land under cultivation being small, each family uses only enough to provide itself with food, except in districts where there is an established cash crop such as cotton or sesame, and a small additional acreage is cultivated. *Shambas* are normally used for only two or three years and then allowed to revert to grass or bush. A typical cropping system is:—

1st year: Short rains: Sesame or legumes.

2nd year: Long rains: Maize, sorghum, and finger millet.

2nd year: Short rains: Sweet potatoes.

3rd year: Long rains: Maize and sorghum.

3rd year: Short rains: Sweet potatoes.

The system starts with the short rains, as new land is usually broken up after the main long rains crops have been planted. It naturally varies considerably according to the climate and soil, an extreme case being at Kadimu in Central Kavirondo where much of the soil is so poor that it can only be cropped for one year. The type of plant growth which appears in abandoned *shambas* also varies, but over that very large area where *Cymbopogon* sp. is naturally the dominant grass, for example between Kakamega, Mumias and Malakisi, reversion follows the lines of—

1st year: Weeds and *Digitaria* sp.,
2nd year: *Imperata cylindrica,*
3rd year: *Cymbopogon* sp.,

and it is remarkable that not only are *Imperata cylindrica* and *Cymbopogon* sp. dominant during the periods in which they occur, but they often exist as almost pure stands. Eventually the hardier bushes and small trees of the Combretum savanna type reappear.

It is difficult to give any figure for the resting period of the land after its reversion, but it seems probable that it is at least sufficient to permit of the recovery of the soil from the moderate demands made on it by the crops taken off. In such circumstances the danger of rapid deterioration of the soil is not formidable, especially as the wide choice of land for cultivation results in most *shambas* being situated on gently sloping land. This minimizes the tendency to erode, and makes erosion controllable by simple methods and a small expenditure of energy on the part of the cultivator. With an increasing acceptance by the native of the necessity for such soil control measures, the prohibition of indiscriminate tree felling and grass burning, and the encouragement of the use of manure and compost, there is little danger of soil conservation becoming a major problem in the more sparsely populated districts. There are of course occasional patches of soil which from treading by cattle, overgrazing or other causes have been damaged in the past, but these are gradually being reconditioned either by the communal efforts of the natives themselves or by labour paid from Local Native Council funds. This is attended by no difficulties arising from the system of land tenure, since such a thing can scarcely be said to exist, all grazing being communal and individual rights to land being recognized only so long as any particular piece is under cultivation.

(2) *Moderately Populated Districts.*—In these the cropping system and the virtual lack of system of land tenure differ little from those in the more sparsely populated districts, except that the clan elders have considerable control over the allocation of land to individuals. There is naturally, however, a greater potential danger of over-grazing and of treading erosion, of the depletion of the plant food reserves in the soil by prolonged cultivation and of the use of steeply sloping land for *shambas*; and consequently an increasingly urgent necessity for the application of mixed farming principles by the natives, in order that grazing may be conserved, the soil used to the best advantage and its productivity maintained by manuring and the use of compost. At the same time these principles are not easy to inculcate in a native mentality slow to appreciate the impending danger, distrustful of new ideas, and averse from them when they entail additional labour.

(3) *Densely Populated Districts.*—In these all the land is individually owned; in some locations sales of land for cash take place between natives and are recognized as permanent. Not even such graz-

ing as results from the temporary abandonment of cultivation is communal, although provided it is not fenced in or the owner's cattle are not tethered on it, it is customary for the cattle of other natives to graze it. Only a small percentage of the land can be termed grazing, and this consists in the main of steep and rocky hillsides, swampy river beds, surrounds of schools and churches, and occasional football fields; with the exception of the hillsides, which are usually covered with *Cymbopogon* sp., it consists of lawn-like sward kept permanently in this state by intensive grazing. The proportion of cultivated land which is allowed to rest is but a small percentage of the total and rarely reverts to grass. At the most it has a weed fallow of a year or less, or in a few cases it is allowed to become covered with the succeeding growth of *Imperata cylindrica,* which is cut for thatching. So great is the extent of cultivation that very steep slopes, very rocky land, and even odd patches of soil on the sides and tops of hills are under almost continuous cultivation, with a consequent rapid exhaustion of the soil and increase of erodibility. The exhaustion of the soil is visible in the very sparse weed growth which occurs on the infrequent patches of fallow land, and the natives themselves comment on the decreasing yields of their crops.

In view of the large amount of unsuitable land under cultivation, soil conservation presents difficulties which do not occur in the more sparsely populated districts, and it is improbable that cultivation of this unsuitable land could be prohibited without hardship to the natives concerned, or that measures which did not include a considerable reduction of the population could be really effective. There is already some tendency to emigrate, but it is insufficient to relieve the situation. The real necessity is for larger average holdings, which would enable the natives to confine their cultivation to suitable land, would allow of a proper rotation of crops and resting period, and would provide grazing for a small herd of cattle. Even as things are now, some improvement would be effected were it possible to confine cultivation to the tops and higher slopes of the ridges, using the bottoms and steeper lower slopes for pasturing with paddocks, and taking advantage of the reeds, of which there are usually plenty in the streams, for litter for compost-making. An analysis of human and stock population of North Kavirondo is given in the annexed table in terms of three arbitrary degrees of density.

Density	Average population	Cattle per sq. mile	Cattle per person	Acres per unit
Sparse :				
Pastoral ..	80	346	4·4	1·5
Agricultural ..	120	190	1·6	2·1
Total ..	90	292	3·1	1·7
Moderate ..	210	150	0·7	1·8
Dense	650	196	0·3	0·7

The figures in the last column are obtained by dividing the total area under consideration by the total of the human and stock populations. If it be assumed that the amount of land required by each native for cultivation is one acre, then the available area for each head of stock is:—

	Acres
Sparse, pastoral	1.6
Sparse, agricultural ...	2.7
Sparse, total	1.9
Moderate	2.9
Dense	—
Average for district ...	1.9

In other words, if the human and stock population of North Kavirondo was uniformly distributed throughout the district, a family of three owning 5 head of cattle

would have at its disposal approximately 13 acres of land, of which three acres would be under cultivation and ten acres grazing.

In contrast with this there are the very densely populated parts, with over one thousand people to the square mile, equivalent to about half an acre of land per person exclusive of cattle.

Soil Conservation Methods

The one most generally in use is the digging of contour trenches, stopped at intervals of not more than 20 ft., the earth removed being used to form a bank on the lower side which is planted with Napier grass, *Cymbopogon* sp., *Paspalum* sp., or some other easily available plant the roots of which will bind the soil. Of these, Napier grass has the advantage that once established it can be cut back from time to time and used for cattle fodder, a considerable benefit where grazing is scarce. The earth bank is gradually built up with silt from the trench until it reaches the requisite size, when the trench is allowed to silt up, the task of preventing erosion devolving on the bank. In time more soil will be retained on the top side of the bank until there is a considerable space which is level, and on this silt will continue to be deposited whenever there is heavy rain, owing to the decrease in the run-off velocity of the surplus water due to its encountering the line of grass.

Where available, trash from the previous crop is used to make temporary contour lines; this, however, has its limitation in that in the drier districts, where supplies of firewood are small, almost all the dry maize and sorghum stalks are used for fuel.

On stony ground rock walls are built along the contour, and in the more sparsely populated districts where there is no shortage of land for cultivation strips of grass or bush are left at intervals down the slope to restrain any movement of soil.

In addition to these methods for assisting the absorption of the excess rain which actually falls on cultivated soil, it is necessary to deal with what may be termed—

Nuclei of Erosion

Among these are:—

(*a*) Stony hillsides.
(*b*) Rock or murram outcrops.
(*c*) Buildings, especially if they have hard bare surrounds.
(*d*) Paths.
(*e*) Boundary furrows between *shambas*.
(*f*) Take-off drains from roads.
(*g*) Over-grazed areas.
(*h*) Ant-hills.
(*i*) Inefficient soil control measures on cultivated land.

With these the following measures are employed to minimize erosion:—

(*a*) *Stony hillsides.*—Tree planting on the tops of the hills and in strips along the sides. Rock walls wherever there is cultivation, and the improvement of ground cover where the land is under bush or grass. In many cases, however, slopes are so steep and the amount of rock so large that some run-off is inevitable, and storm drains at the base of the hill are essential in order to protect arable land below.

(*b*) *Rock or murram outcrops.*—Tree planting as near as possible to the outcrops and among the rocks if, as is usual, they are interspersed with patches of soil, so that the leaf canopy may break the fall of heavy rain. The diversion of surplus water by means of storm drains.

(*c*) *Buildings.*—Storm drains where possible, and in districts where bananas are planted on the lower sides of villages, the use of banana trash in contour lines to check run-off and increase absorption.

(*d*) *Paths.*—Natives are encouraged to fence along both sides of the main paths with quick- and close-growing material such as *Euphorbia* sp., *Dracaena* sp., and *Coleus* sp., to prevent erosion from the adjoining *shambas* which are considerably higher than the paths, to build turf banks to reduce the speed of run-off, and to allow grass to grow between.

(*e*) *Boundary furrows between shambas.*—These are of almost universal occurrence throughout the Kavirondo country, and generally run down hill, frequently from the top of a ridge to the bottom. They are caused in the first instance by adjoining land-holders scraping the earth at their joint boundary towards their respective *shambas* in order to demarcate the boundary. This results in a shallow trench which increases with each year's cultivation and erosion until it may eventually become three or four feet deep. As the furrow deepens, the soil on both sides is washed down, and often there is a strip of two or three yards wide on either side which is down to subsoil and will produce nothing. Nevertheless, these slopes are cultivated by the owners, partly to prevent couch spreading from them to the *shamba* proper, and partly owing to the fear that otherwise the adjoining land-holder would encroach. Natives are encouraged to refrain from cultivating the slopes, to build earth or turf banks across the furrows, and to plant them with hedges of quick-growing indigenous plants.

(*f*) *Take-off drains from roads* are stopped at close intervals with low turf banks to reduce the velocity of the run-off, and grass is allowed to grow between. Precautions are taken to see that the top of the first bank is far enough below the surface of the road to obviate flooding. Cultivation of the land within a few feet of either side of the drain and for some distance below the spillway is discouraged.

(*g*) *Over-grazed areas* are improved where possible by destocking, by digging short trenches at intervals to retain surplus water and so increase the soil moisture, and where necessary by the planting of suitable grasses, *Cynodon, Paspalum, Pennisetum,* etc.

(*h*) *Ant-hills* are dangerous in that their steep slopes prevent absorption of rain during storms and increase the amount of water round the bases. Natives are encouraged to refrain from cultivating them.

(*i*) *Inefficient soil control measures.*—These sometimes occur where the willingness of the individual native to undertake the work is greater than his capacity to carry it out effectively, and will disappear in the course of time as his standard of education in agricultural practice is improved.

It will be realized that the efforts of the individual cultivator are in the circumstances not enough in themselves, and that not only is a certain amount of communal effort necessary but also a good deal of co-operation between owners of adjoining holdings. As to the former,

it is obviously useless for the owners of land at the bottom of a steep rocky hill from which the run-off is considerable to carry out soil control measures on their cultivated land, however satisfactory these measures may be in themselves, unless the land is first protected from storm water from the hill. The work involved in such protective measures should devolve equally on all holders of the land affected by them. Similarly as regards co-operation, it is a waste of energy on the part of *A* at the bottom of a slope to put in control measures which would be effective in respect of his own land, if *B* higher up does nothing to prevent the storm water from his land pouring down and destroying *A*'s work. While there is no doubt that in general the necessity for soil control is accepted by the natives, it is not always easy to obtain that concerted effort which produces the best results with the least expenditure of energy. A minor obstacle is that the wealthier natives, such as traders, teachers and artisans, who are frequently large land-holders, are often unwilling to undertake the manual work entailed by soil control measures themselves and are loath to utilize their paid labour for such work. It can, however, be said with confidence that the propaganda and demonstrational work of the last few years has produced such an effect on the native mind that the practical application of soil control measures in the reserves is increasing with gratifying rapidity.

I am greatly indebted to Mr. W. Lyne Watt, Senior Agricultural Officer, Nyanza Province, and to Mr. T. Y. Watson, Agricultural Officer, Kakamega, for suggestions and helpful criticism in connexion with these notes.

Correspondence

The Editor,

E.A. Agricultural Journal.

Dear Sir,

In a recent issue you published an article on the Housing of Native Labour in the tropics. I have no doubt the accommodation provided for the labour on your contributor's farm is excellent in every way, except one: Are the houses really appreciated by the natives who live in them?

The iron roof is the trouble. It is too cold by night and too hot by day. I don't believe it is healthy and the native doesn't either. The real reason we build iron-roofed huts is to suit ourselves. Iron is more or less permanent, and will therefore have low depreciation. It is also neat and clean. The labour officer finds no cause for complaint.

Build your walls in brick, stone or whatever material is most economic in your district, as your article advocates. Thatch is still the best roof in most circumstances. "Rats," you say; "Cats," say I.

Supposing the type of building is on the lines of the hut the native is used to in his reserves. You improve on that by giving it good permanent walls and floor. Even if the grass has to be carted long distances the cost should not be more than Sh. 30 per hut (of about 15 ft. diameter), or Sh. 3 or Sh. 4 per annum.

I am tempted to write much more on the subject of labour housing, but as thatch is condemned by the Labour Department you will probably not care for my views.

I am,
Yours, etc.,
X.Y.Z.

Rondavel Hut Construction

By M. D. GRAHAM, *Assistant Agricultural Officer, Kenya*
Photographs by Author; other Illustrations by W. LYNE WATT, *Senior Agricultural Officer, Kenya*

Buildings of this type have been constructed at the Agricultural Training School, Bukura, with a view to ascertaining both their suitability for native quarters and their permanency. Both the single and the double units (Figs. 1 and 6) have proved most satisfactory. The initial expense of erection is very little higher than the cost of putting up wattle-and-daub huts. The result is a neat building, healthy and permanent. A trained mason or carpenter is not necessary; any intelligent native could construct such a building.

The walls are built from green bricks or clay blocks measuring 12 in. x 9 in. x 6 in. Most soils would be suitable, although clay is no doubt the most satisfactory material to use. Where good clay is not available, chopped grass should be mixed with the earth and the whole well puddled. It is essential that the material to be used for the blocks should be well puddled and the best way to ensure this is to mix and puddle one day, leave overnight and puddle again the following morning before moulding. The material should be as stiff as possible, as this minimizes cracking when drying.

Moulding of the blocks should proceed as with ordinary brick-making. A three-compartment mould is the most satisfactory. A drying shed is, of course, essential. It is also essential that the blocks should be perfectly dry before building, otherwise cracked walls result.

The foundations offer the only difficulty which an untrained mason might experience. These should be very carefully marked out and the trench sides cut truly and vertically. This saves trouble and time in the end. Foundation trenches need not be more than 12 in. deep and 15 in. wide, as the weight supported is not great. A rubble foundation is all that is required, and no skill is called for in packing and ramming in the stones. The work should be completed with small stones and chips, and finished off with a course of cement. To prevent dampness, the foundation should be finished off above ground level, and must be level.

FIG. 1
Single Unit. Gross cost Sh. 116/05. Internal diameter 13 ft. Height of walls 6 ft.

In marking out the foundations of a double-unit house, each house having a 13 ft. internal diameter, proceed as follows:—

Drive in two pegs on the cleared site, 13 ft. apart. Attach a piece of string to one of the pegs. To the other end of the string tie a pointed stick or a 6 in. nail. From peg to nail the length of the string

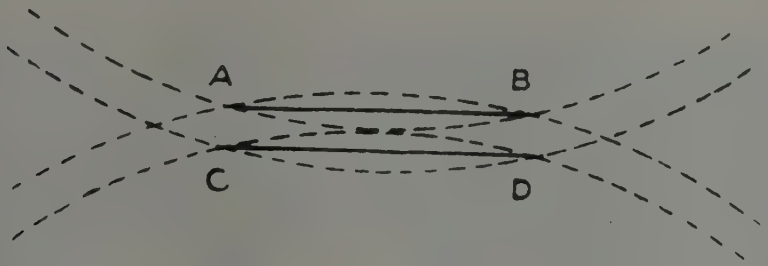


FIG. 2

is 6 ft. 3 in. Now describe a circle. Do the same thing, using the second peg as the centre. These lines form the inner perimeter of the foundation. Now increase the length of the string to 6 ft. 9 in. Describe two circles as before. At the points of intersection of the circles, two straight lines are drawn from A to B and from C to D, so that where the two walls meet there will be a section of straight wall 4 ft. 9 in. long (Fig. 2).

When building commences, centre poles are put in where the original pegs were for marking out the foundations. The poles should be perfectly straight. An 8 ft. length of 1 in. piping is ideal. This must be vertical and should be plumbed each morning before work commences. Cut a straight stick 6 ft. 5 in. in length and fix it horizontally to the upright pole in such a manner that this horizontal stick can swivel on the upright member. A piece of hoop-iron bent round and nailed to the stick is ideal. A string attached to this arm and fastened to a swivel at the top of the upright holds it in position (Fig. 3).

This gives an infallible and constant measure for building. As each course of bricks is laid the string is shortened and the horizontal arm lifted, at the same time maintaining it horizontal. Such a method dispenses with levels and plumbs because, provided the arm is horizontal and the upright vertical, the walls must be a perfect circle and plumb.

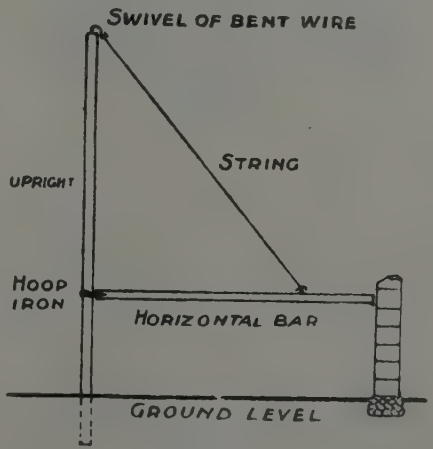


FIG. 3

The junction of the two walls may appear to offer some difficulty. In practice, however, there is none. The junction of the two roofs does not offer any difficulty. When the roofing poles have been put on, a 6 ft. length of galvanized iron, 18 in. broad, bent to form a gutter, is laid over the junction and thatching proceeds normally, so that this section of tin is covered (Figs. 4 and 5). It forms a secure and watertight joint.

The walls are plastered with a mixture of half clay and half sand, to prevent cracking. In order to waterproof them, make a thin slurry of pure cement, with some common salt added, mixed to the consistency of whitewash. Using a whitewash brush, paint the outer walls with this cement mixture. It takes only a few pounds of cement to do the walls of both rondavels.

FIG. 4
Showing the roof junction from inside (double unit.) Note tin in the valley

SPECIFICATIONS AND GROSS COSTS

1—*Single Rondavel Specifications and Materials Used*

(*a*) 400 earth blocks, 12 in. x 9 in. x 6 in.
(*b*) Grass roof; wattle or gum poles used for roofing timbers and laths.
(*c*) Internal diameter: 13 ft.
(*d*) Height of walls: 6 ft.
(*e*) One batten door and one batten window made from 6 in. x 1 in. podo or cedar; door and window frames made from 4 in. x 3 in. timber.
(*f*) Door is full height of wall, less the frame; window is 3 ft. x 2 ft. 3 in.
(*g*) Floor of beaten murram; a cement skin overlay costs very little more.

(*h*) Wall plastered inside and outside with mixture of half clay and half sand. Outer surfaces cement-washed; inner surfaces lime-washed.

2—*Cost of Bricks*

	Sh. cts.	*Sh. cts.*
(1) 400 bricks made by 23 labourers at Cts. 30 per day ..	6 90	
(2) Transport of building materials—		
(*a*) Use of cart	2 00	
(*b*) Use of oxen and gear ..	2 00	
(*c*) Labour	1 20	
		12 10

3—*Building*

(*a*) Foundation—		
(1) Cement, one-third of drum	8 50	
(2) Sand and stone, labour in collecting and transport ..	3 00	
(3) 1 mason for 3 days at Sh. 2 per day	6 00	
(4) 2 labourers for 3 days at Cts. 30 each	1 80	
		19 30
(*b*) Bricklaying—		
400 bricks laid in 3 days by 1 mason and 2 labourers ..		7 80
(*c*) Plastering—		
(1) Mixing and preparation ..	1 50	
(2) *Fundi* for 3 days at Sh. 2 per day and 2 labourers for 3 days at Cts. 30 each per day	7 80	
(3) Cost of cement wash, white wash, and labour in applying	2 20	
		11 50
(*d*) Floor—		
(1) Mason for 1½ days and 2 labourers	4 20	
(2) Sand and cement used ..	5 00	
		9 20
(*e*) Timber—		
(1) Solignum used	0 50	
(2) Timber in door and frame and window and frame, hinges, nails and screws ..	16 65	
		17 15

4—*Thatching and Roofing*

	Sh. cts.	*Sh. cts.*
(*a*) Cutting and transporting poles	1 00	
(*b*) Cost of grass	20 00	
(*c*) Cost of thatching twine ..	2 50	
(*d*) Labour preparing grass and thatching	6 60	
(*e*) *Fundi* erecting roof and labour; nails	3 90	
(*f*) Value of poles and laths ..	5 00	
		39 00
Grand Total ..		116 05

FIG. 5
Double unit. Roof junction. Thatch covers the tin in valley

NOTE

The gross costs have been given, and all were taken from the first single and the first double units built. Other rondavels of both types have since been built, and it is known that the costs of construction were very appreciably reduced. The net cost or actual cash outlay amounts to the sawn timber for doors, windows and frames, cement and labour

in building. The net cost is therefore considerably lower. The poles, etc., used have been given a value, whereas where available they can hardly be given a cash value unless marketable. Except for the *fundi*, only unskilled labour was used. The *fundi* is a native and a trained carpenter whose knowledge of stone and

A single rondavel costs more, proportionately than a double unit, so that in estimating costs from the above figures for the double unit, 20 per cent of the doubled figure should be subtracted.

In comparing these costs with the building of an ordinary wattle-and-daub native hut, the main difference is in the

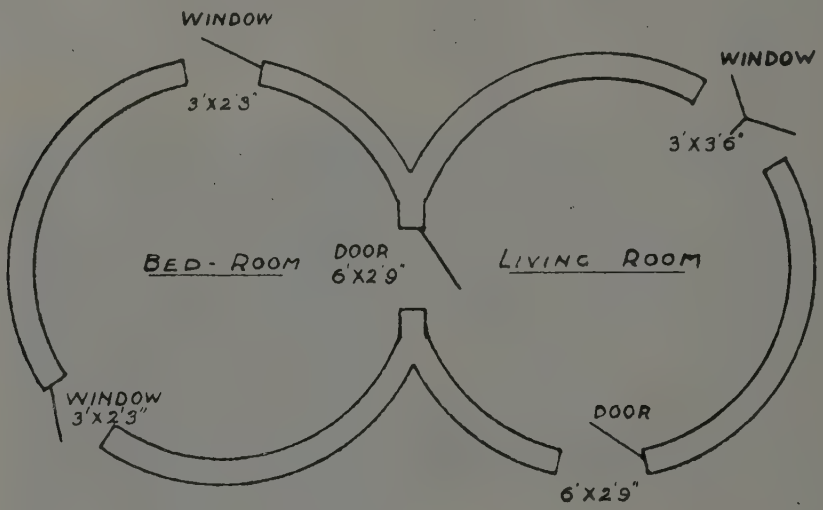


FIG. 6
Plan of double unit

brick masonry is slight. After completing one single and one double unit, he was able to build others without any supervision, including the marking out, cutting and building of foundations.

The cost of the thatching must be considered as the same whether for a wattle-and-daub hut or a rondavel of the type described. In the table of costs the cost of thatching was very high, as all grass had to be bought from a contractor.

foundation of the rondavel, costing Sh. 19/30. The cost of bricklaying is less than the cost of building the walls of the wattle-and-daub hut. The cut timber, nails, screws, etc., are an expense incurred only in the rondavel, unless proper doors are fitted to the wattle-and-daub hut. It will be seen therefore that the rondavel costs very little more than the hut, and is a permanent and far healthier building.

The Uses of Statistics in Field Experiments with Rubber Trees*

By H. J. PAGE

There is an old gibe that there are three grades of falsehood:—"Lies, Damned Lies and Statistics". The intention here is to show that statistics, properly used, so far from being the acme of falsehood, is indeed common-sense in a highly developed degree. Huxley defined science as "organized common-sense", and this is a definition which is specially appropriate here, for the application of statistics to field experiments has made it possible to carry these out in a scientific manner not before possible, and to interpret their results with a high degree of scientific precision. Statistics have in fact brought a large amount of common-sense to bear on the conduct and interpretation of field experiments.

It must of course be understood that the term statistics is used here not in the loose sense of the mere collection and classification of numerical data, but in the specialized sense of the use of higher mathematics for the analysis and interpretation of data, and for the design of experiments. It is not intended to attempt to explain the mathematical principles involved or the manner of their use. That is the job of the higher mathematician himself—so much so that although other scientists have to understand the general principles of the application of statistics to the design and interpretation of experiments, it is nowadays best left to the specialized mathematical statistician to undertake the actual work of applying his methods. It is for that reason that the Rubber Research Institute has just appointed a Statistician to its staff.

WHAT IS AN EXPERIMENT?

An experiment is defined in Webster as: "A trial . . . made to confirm or disprove something doubtful"—and in the case of rubber-growing, the "something doubtful" is whether a certain method of treatment or a certain type of material is better than others, and therefore worth while to adopt.

Anyone can carry out an experiment, and can obtain results therefrom. But that is less than half the battle. The experiment may have been so badly designed or so badly conducted that it cannot possibly give results capable of valid interpretation; or it may have been well designed and executed, and yet the meaning of the results may be obscure or misunderstood.

Let us take as our first example an experiment intended to compare only two things—or "treatments" as they are usually termed—for instance to compare the yielding power of one clone with that of another, or with that of seedlings, or to ascertain the relative merits of two tapping systems, or the effect of a given fertilizer on the yield of rubber trees. What would appear at first sight to be the obvious way of doing this would be to take two adjacent plots of land as alike as possible, and to apply the two treatments one to each, and then to compare the results obtained.

Now the crux of the whole matter is that more often than not this is an entirely misleading and unreliable way of doing a field experiment, and the chief object of this paper is to explain why this is so.

*The substance of a lecture at the Annual Conference of the Incorporated Society of Planters at Kuala Lumpur on 17th September, 1937. Reprinted from the *Journal of the Rubber Research Institute of Malaya*, Vol. 8, No. 2.

"Single-Plot" Experiments

The practical man is strengthened in his unwillingness to accept this verdict by the fact that the earliest and best known agricultural field experiments were carried out in this way, as "single-plot" experiments; that is, with only one plot for each treatment. Many of the most important advances in scientific agricultural practice are based on the results of such "single-plot" experiments. The world-famous manuring experiment on Broadbalk Field at Rothamsted for instance, from the results of which our knowledge of the main principles of manuring was first derived, is a "single-plot" experiment, started in 1843 and is still going on.

The reason for this is that if the effects which the experiment is intended to study are big enough, "single-plot" experiments will establish them with sufficient certainty. The Broadbalk experiments just referred to showed increases in yield of the order of 50 or 100 per cent more—in fact at the present time the plot receiving no manure gives barely ten bushels, whilst the plot getting a liberal "complete" manuring gives over thirty bushels: an increase of about 200 per cent over the control! If we knew beforehand that the effects to be studied in our field experiments were always as big as that, we could probably do well enough with "single-plot" experiments, if indeed we should then bother to do any experiments at all! But unfortunately the effects we wish to measure nowadays are more often only a matter of differences of 10 or 20 per cent instead of 100 or 200 per cent. They may be no less important for all that. A 20 per cent increase in yield of rubber, yielding before treatment 400 lb. per acre, i.e. an increase of 80 lb. per acre, may represent a handsome profit, perhaps 100 per cent on the cost of getting it. But an increase of 20 per cent usually cannot be detected with certainty from a "single-plot" experiment.

Two adjacent tasks, one of which is manured and the other not, may give yields of 400 and 480 lb. rubber respectively, and yet the difference may have nothing whatever to do with the manuring. Even if previous records for the two tasks indicated that they then both gave 400 lb., the difference of 80 lb. after manuring may have been due to other factors entirely unconnected with the manuring. Moreover, unless special steps have been taken to ensure that the previous records do actually represent the true yields of the two tasks, there is no guarantee that they do; for tappers are notoriously prone to level up their deliveries of latex from adjoining tasks. All the same, as explained later, the existence of previous records does help to improve the reliability and to simplify the layout of experiments on mature rubber. But for "single-plot" experiments for which suitable past yield-records are not available, such as comparisons of different planting material; or cultivation and manuring experiments on young rubber; one is entirely at the mercy of the variations in the fertility of the soil over the area chosen for the experiment, as well as many other varying factors outside one's control.

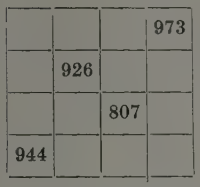
Plot Variability. "Uniformity" Trials

Before going any further to explain this, a few examples follow:—

Nos. I–V show the yields from the untreated control plots from various experiments.

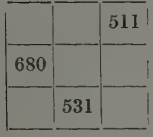
Nos. VI–VIII show the yields from adjoining plots, or "uniformity trials".

I



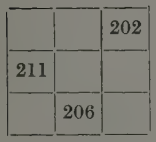
Difference between adjacent plots in centre=14 per cent.

II



Difference between adjacent plots=25 per cent.

III



Exceptional uniformity.

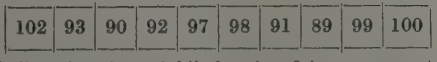
IV

Right-hand plot 35 per cent in excess of other two.

V

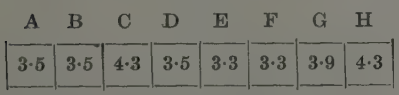
Good agreement of adjacent plots in two cases, but 14 per cent difference in the third case, and a pronounced "drift" from high yields on left to low yields on right.

VI



A "uniformity trial" showing fair agreement, but a range of 13 per cent between highest and lowest yields.

VII



Yields from adjacent tasks (in gms. per 100 trees per tapping).

Differences between adjoining tasks, and the same as percentages, are shown below.

Nil	0·8	0·8	0·2	Nil	0·6	0·4
—	20	20	5	—	15	10%

VIII

A uniformity trial of 78 plots. The yield showed a total range of variation of nearly 60 per cent, and examples of yields from adjacent plots are as follows:—

73
133 } Difference=58 per cent of mean.

103
84 } Difference=18 per cent of mean.

84
112 } Difference=28 per cent of mean.

89
117 } Difference=27 per cent of mean.

106
79 } Difference=29 per cent of mean.

115
83 } Difference=32 per cent of mean.

These are all actual instances of the yields obtained from adjoining or closely situated tasks of rubber, to which no different experimental treatments have been applied, i.e. which have been treated, as nearly as practicable, exactly alike. Admittedly some of these are chosen deliberately as horrid examples, but they are none the less actual instances of the variation that may occur. Others of the examples displayed show that sometimes there may be a high degree of uniformity. The point is that one never knows with even reasonable certainty what the extent of this natural variation is. All the areas in question were chosen to represent the most uniform land and rubber available on the estate. This is an effectual answer to the planter who insists on using only single plots; and who says: "The other chap may have to use an elaborate modern experiment to get results, but I know my soil and my rubber so well that I can rely on the results of single plots". That is as often as not just sheer nonsense. Agricultural scientists have found by bitter experience that even on the most level and uniform-looking land, with apparently uniform planting material, be it an annual crop or perennial, differences in yield of the order of those shown on the diagrams are only too

commonly found. Originally agricultural scientists were just as unwilling and reluctant as the farmer or planter, to adopt the modern type of elaborate lay-out of field experiments. The remark of a certain distinguished professor of agriculture: "Damn your duplicate plot, give me single plots and I know where I am", is typical of the attitude which has had to be given up after hard experience. He thought he knew where he was, but more often than not he would have been quite wrong.

The reason for this uncertainty is that with all natural material, living or inanimate, there is a greater or less degree of variability, which is not the case with pure substances. The chemist working with pure substances is largely free from this trouble. He does not have to do an experiment, for instance, to find out whether sulphuric acid and caustic soda will react together and neutralize one another. He knows that they always will; that 98 grams of H_2SO_4 will always be exactly neutralized by 80 grams of NaOH to give 142 grams of Na_2SO_4; and that a fixed and constant amount of heat will be liberated. All molecules of sulphuric acid or of caustic soda are chemically alike. But no two individuals of any living kind are exactly the same, nor are any two samples of natural material, and the behaviour of an individual or a sample cannot be predicted with certainty. It is this innate variability of natural material, and the environmental conditions, which places experimentation with such materials, and particularly with living materials, on an entirely different plane from experimentation with pure substances. The statistician's job is to study variability and its effects, and it is for that reason that the assistance of statistics is so necessary in the design and interpretation of field experiments.

Factors Responsible for Variation

Let us examine the factors responsible for variation in field experiments with rubber trees. In the first place there is the variation in "fertility" between different plots of land. In a properly-designed experiment this is the biggest source of variation. Even the most uniform-looking area of land may possess quite big variations from one place to another. Even if the surface soil is quite flat and apparently uniform, there may be invisible differences in the nature and depth of the subsoil. The sporadic occurrence of a hard pan, at varying depths, is a special case of this, and instances often occur in which the existence of such a hard pan is first discovered only as a result of poor sickly growth of trees in patches. Moreover, an apparently uniform top soil, of uniform depth, may yet hide differences in fertility through differences in the previous cropping history of the area; a part may have been heavily depleted of available plant food by previous cropping with, say, tapioca. On many estates it is practically impossible to find any level areas of land, and experimental areas have to be on hillsides, with considerable differences in the soil, and in conditions such as drainage, between the higher and the lower land.

Added to these inherent variations in the soil, are variations in the rubber trees. By choosing plots of the size of a task, with over 200 trees, the effect of the large tree-to-tree variability, which occurs especially with seedling rubber, is largely eliminated; and differences in age or origin of trees should always be avoided by choosing an area which was all planted at the same time with uniform material (except of course in an experiment for the comparison of different sort of planting material). There still remain the effects of uneven attack by

pests and diseases, of differences in tapping history or in average height of tapping, whilst there is also the possibilty of lack of uniformity in the conduct of the experiment and in the collection of the results.

Size of Uncontrollable Variation

The uncontrollable variation due to differences in soil and subsoil—or "soil heterogeneity" as it is usually called—will sometimes be slight and sometimes be large, whilst the other factors instanced above will similarly differ in their incidence from place to place and time to time. Thus the sum total of the effects of all these factors, as reflected in the growth or yield data obtained from the plots, will also vary between wide limits, as shown by the examples above, where in some cases the yields show a very satisfactory approach to uniformity, as between different plots, whilst in other cases the differences may be over 25 per cent. The important point is that one can never be sure beforehand what the position is.

Suppose that the two plots A and B of example VII above had been chosen to compare two clones, and that a difference of 20 per cent had shown up between them in growth, or in yield when they came to tapping, then one would in fact be reasonably safe in drawing the conclusion that the two clones did actually differ, on that soil, by about 20 per cent in their growth or yield. On the other hand, suppose that plots C and D had been chosen, without the knowledge which the "uniformity" test has here revealed. The two clones might be identical in their inherent yielding capacity, and yet the natural "soil heterogeneity" between the two plots would result in a difference of 20 per cent, which would be quite erroneously interpreted as a difference in the clones themselves, if the results of only that one single-plot experiment were accepted as valid.

This is sufficient to demonstrate how unsafe it is to rely on the results of "single-plot" experiments—save under certain special circumstances later.

Regular and Irregular Variation

Uniformity trials such as those which are represented above, are trials in which the area in question is divided up into plots which are harvested separately, without and difference in treatment. These enable *fertility contour diagrams* to be drawn. These are similar to the height contours so familiar on ordinary maps. There are peaks of high fertility, hollows and valleys of low fertility, and intermediate slopes of average fertility. Now if changes of fertility of this sort occur *within* one experimental area, it is clear that the variation from plot to plot is irregular, though contiguous plots are likely to be less different than those more widely separated.

On the other hand the scale of the fertility contour map may be smaller, so that the whole of an experimental area falls on a patch of regularly varying fertility. The pitfalls into which a regular fertility gradient or "drift" of this kind can lead, are well illustrated by a case recorded some years ago, which is illustrated below.

0	10	20	30	40	50		Cwt. of lime per acre.
A	B	C	D	E	F	X	
20	22	24	26	28	30		Yield.

There were seven plots in a row, the first receiving no treatment, and five others receiving, in order, 10, 20, 30, 40 and 50 cwt. of lime per acre. The yields obtained may be represented by the figures underneath the plots, e.g. a steady increase in yield from 20 to 22, 24, 26,

28 and 30 units—apparently a clear case of increasing benefit to the yield from increasing amounts of lime. Fortunately (or unfortunately!) a second control plot was included at the other end, marked X on the diagram. The yield from that control plot was 32! The lime had really no effect on yield at all; all that the experiment showed was a uniform fertility drift increasing from left to right. But for the afterthought of adding a duplicate control plot at the other end, this would not have been discovered, and it would have been concluded that lime had an increasingly beneficial effect on that soil, in dressings at least up to 50 cwt. per acre.

It might have happened, however, that the experiment was laid out on land with a peak of high fertility in the middle, in which case the two control plots one at each end would have given similar yields, and it would have been concluded that the land was of uniform fertility, unless another control plot had been included in the middle to reveal a yield much higher than those from the plots at the two ends.

One of the earliest methods of guarding against misleading results of this kind was to make every other plot a control plot, as below.

A	B	A	C	A	D	A	E	A	F	A

A=Control plots.
B, C, D, etc.=Treated plots.

Then by comparing the yield of each treated plot with the average of the yields of the two control plots one on each side, a more accurate measure of the treatment was obtained. But what a wasteful and cumbrous method of experimenting! Half the total number of plots is given up untreated to controls, and there is still only one single plot for each treatment. All the same, this was a definite move in the right direction, for it introduced the principle of repetition, or "replication" as it is now called (as a useful word to cover duplication, triplication, and so on, up to any desired degree of repetition).

Replication

In view of the chances of variation between plots, it is obvious that if there are *several* of each treatment, distributed over the whole area, the *average* result obtained from all the replicate plots of any one treatment is much more likely to represent the real yield obtainable with that treatment under the average conditions of that area, and comparison between such averages for different treatments is far more likely to be a true indication of the relative effects of those treatments.

Replication is the first essential of a reliable field experiment, and in all modern experiments each treatment (including the control, if any) is replicated the same number of times. Let us take four-fold replication (that is, quadruplication), as an example. In the following diagram is an experiment with four treatments, A, B, C and D, with four plots for each treatment.

A	B	C	D
D	A	B	C
C	D	A	B
B	C	D	A

This is typical of the kind of experiment first adopted after the need for replication came to be recognized. It includes adequate replication, but its arrangement is *systematic*. A, B, C and D always follow one another in the same order.

Experimental Error

Now we have seen that owing to "soil heterogeneity" and other uncontrollable factors, the results obtained from an experiment are lacking in accuracy to a greater or less degree. The extent to which the results are therefore not completely accurate is the "experimental error", termed mathematically the "standard error" or the "probable error" according to the mathematical convention used to calculate it. It is expressed as ± X, where X is a number; the higher X is, the more inaccurate the experiment is and the less reliable are the results. A probable error of say ± 10 per cent applying to an average yield of say 100 units from a given treatment, means that owing to the influence of uncontrolled variation in the conditions of the experiment, that average is inaccurate, and that there is a good chance that the true value might be only 90 on the one hand, or 110 on the other, or anywhere between; it is impossible to say, between those limits just what it really should be.

The object of a properly-designed field experiment, so far as the experimental error is concerned, is not only to make that error as low as possible, but also, *equally important*, to make it possible to calculate that error accurately. The use to which the results of an experiment are put is to decide how the effects of different treatments compare. This involves studying the *differences* between the average results for the two treatments under comparison. Supposing one treatment gives an average of 100 and another an average of 120. If the "probable error" of each is ± 10 per cent, that means that the treatment with the average of 100 may be taken as being possibly anything from 90–110, and the other as anything from 108–132. The difference between the averages for the treatments may therefore be anything from −2 to +42! The apparent superiority of 20 per cent of the second treatment over the first has changed into the complete uncertainty, whether perhaps it is no better, or whether perhaps it is very much better. This is taking rather an extreme and crude example—the mathematician has more elegant and exact methods of treatment—but it serves to illustrate my point. Supposing the probable error has been wrongly estimated and that it is really only about 5 per cent instead of 10 per cent, what a difference that would make to the value of the results.

The fault of the systematic arrangement of plots, with replication, is that whilst it reduces the experimental error, it does not allow the true value of that error to be calculated, and as just explained, it is not much use improving the accuracy of results if you do not know what that accuracy is.

Randomization

The other requirement of a properly laid out experiment, in addition to replication, is "*randomization*". That simply means that the arrangement of the plots it not systematic, but at random—according to chance. If the previous diagram is compared with the following one:—

A	D	B	C
D	C	A	B
C	B	D	A
B	A	C	D

it is seen that whilst in the first one, A, B, C and D always come in the same

order in each row or column, in this one that is not so—they are arranged at random in each. The order in which the treatments are assigned, in a randomized arrangement, is one of the many in which they might come if dealt from a shuffled pack of cards, or thrown with dice, or drawn from a hat.

It is a requirement of the mathematical statistics whereby the standard error is worked out, that if the estimate of that error is to be *valid*, the arrangement of treatments in each experiment, or section thereof, must be at random, not systematic. We have seen already that it is not any use calculating the experimental error unless it is really an indication of the true error, and here it must be taken on trust that randomization is essential for that purpose. The mathematical arguments underlying that fact are perfectly sound but far too involved to explain now.

Randomized Blocks and Latin Squares

The commonest and best-known arrangements in which the great majority of properly laid out field experiments are included, are *Randomized Blocks* and *Latin Squares*. Many will be familiar with these from the schemes of experiments they are doing in co-operation with the Rubber Research Institute, the Department of Agriculture or with other concerns. It is hoped that after the attempt to explain why they are necessary, and the further attempt later on to explain how they work, planters will be happier in their minds about what must often have seemed the rather unreasonable requirements and conditions they are asked to conform to in such experiments.

In the case of the *Randomized Block* experiments illustrated below:—

Two Examples of Randomized Block Experiments

(Plot yields shown only for Control [A] Plots)

						Block Totals
Block 1	A 17·5	C	D	B	E	102
,, 2	E	C	B	D	A 27·2	122
,, 3	E	B	D	A 18·7	C	127
,, 4	A 21·8	B	D	C	E	128
,, 5	D	C	E	A 23·6	B	134

Standard error of difference between Treatment Averages—8·8 per cent.

Significant difference between treatment Averages—17·6 per cent.

An example of a Randomized Block experiment showing rather a high experimental error, as was to be expected from the big variation in yields from Control (A) plots.

						Block Totals
Block 1	D	C	E	A 3·2	B	16·6
,, 2	E	C	D	B	A 3·2	16·9
,, 3	C	A 3·2	D	B	E	17·3
,, 4	A 3·1	D	B	C	E	16·7
,, 5	E	B	D	C	A 3·1	16·9

Standard error of difference between treatment averages—2·6 per cent.

Significant difference between treatments averages—5·2 per cent.

An example of a Randomized Block experiment with a low experimental error, as was to be expected from the uniformity in yields from the Control (A) plots, and in Block Totals.

we have five treatments, A, B, C, D, E, and five-fold replication, so that there are five separate blocks. In each block there are five plots, one for each treatment, and the allocation of these treatments is entirely at random, that is, in the order in which they might be drawn from a hat. The random arrangement is different in each block, representing a fresh drawing from the hat for each.

AN EXAMPLE OF A LATIN SQUARE EXPERIMENT

R.R.I. Experiment Station Block 6, 1936

Letters = Treatments

Numbers = Plot Yields

						Row Totals
B 391	A 330	C 374	D 362	F 339	E 372	2,168
C 414	D 399	F 384	E 387	B 392	A 375	2,351
F 395	C 445	E 336	A 391	D 362	B 329	2,258
D 393	B 394	A 383	C 440	E 361	F 386	2,357
A 378	E 373	B 391	F 399	C 390	D 373	2,304
E 337	F 372	D 350	B 397	A 352	C 454	2,262

Column Totals

2,308 2,313 2,218 2,376 2,196 2,289 2,283

		Per cent
Treatment Averages A	.. 368	97
,, ,, B	.. 382	100
,, ,, C	.. 420	110
,, ,, D	.. 373	98
,, ,, E	.. 361	95
,, ,, F	.. 379	100
Standard Error of Difference between Treatment Averages	..	3·44
Significant Difference	..	7·0

The *Latin Square* is a slightly more restricted arrangement, in which the number of replications is the same as the number of treatments. We have such a 6×6 Latin Square illustrated above.

It is not necessarily a geometrical square, for the individual plots may be longer than they are broad, but it is called a square because it has the same number of plots, six, in each direction. It may be regarded as six randomized plots, either vertically or horizontally, and it is so in fact, in so far that the arrangement of the treatments in each row or each column is at random, but with this important restriction, that any one treatment must not occur more than once in any one row or in any one column.

An essential feature of experiments of this type is that the *total* yield for a block (in a Randomized Block experiment) or from a row or column (in a Latin Square experiment) is contributed to by each treatment alike. In the above Latin Square, one-sixth of the area of each row or column is untreated control (A), one-sixth has received treatment B, one-sixth treatment C, and so on; so that all treatments have an equal share in their effect on the block, row or column total. The comparison of these totals thus does not involve main differential treatment effects, and is an indication of the variation due to other uncontrolled factors. Variations in "soil heterogeneity" can be observed from variations in block, row or column total, and by a mathematical treatment of those totals, a large part of the error caused by "soil heterogeneity" and the like can be calculated and can be eliminated from the error attaching to the comparison of the treatment totals, so increasing the accuracy of the experiment.

"SIGNIFICANT DIFFERENCE"

An attempt will now be made to explain what is meant by another term

which is used very frequently in stating and interpreting the results of an experiment, the term "Significant Difference". To do this, it must first be remembered that the irregularities due to "soil heterogeneity" and other causes are distributed more or less at random over the experimental area, and that it is a matter of *chance* whether any particular plot will be on an area which is above or below, and much or little above or below, the average. The mathematical treatment of the results must therefore be one which deals with the assessment of *chances* or *odds*, or as the mathematician calls it, *probability*.

When a "standard error" is said to be ± 10 per cent that does not mean that the result could not possibly be even less accurate than that, but that the odds are in favour of the inaccuracy not exceeding ± 10 per cent. Since there are so many variable factors not under complete control in any experiment: soil, weather, disease, Tamil coolies, etc., and since the incidence of these factors can never be exactly known, there *must* always be *some* uncertainty regarding the accuracy of the results obtained, however well the experiment has been designed and carried out. The object of the application of statistics to the design and to the interpretation of field experiments is to reduce that uncertainty as far as possible, and to define it. This is done by stating the experimental error and the "significant difference" in terms of probability or odds. It is open to anybody to decide what degree of probability he is willing to accept as good enough for him in practice, and circumstances may often dictate whether long odds or short odds are worth while.

The odds that are usually accepted by the scientist in the interpretation of field experiments are *20 to 1, or 95 per cent probability*. ($P = 0.05$.) As explained already, there is always a chance that the difference between the average results for two treatments, even from the best-designed and executed experiment, is caused by chance, i.e. by the operation of the uncontrolled variables included in "soil heterogeneity" etc., and not by the difference in the treatments applied. If the mathematical analysis of the data shows that the odds are 20 or more to 1 that this is not so, i.e. that there is at least 95 per cent probability that the difference *is* caused by the difference in the treatments, then that difference is said to be "significant" and the "significant difference" is the minimum difference allowing these minimum odds.

Any difference between treatment averages which is less than this "significant difference" is "insignificant", i.e. it is not safe enough to ascribe it to the difference in treatments, because the odds against its being caused merely by chance are less than 20 to 1. Anybody who is prepared to take more of a chance, is perfectly at liberty to do so. He may wish to accept 10 to 1 odds instead of 20 to 1, in which case a smaller difference is accepted as caused by the treatments under test.

As in other walks of life, the amount of chance one is prepared to take depends on what is at stake. To take action on a low probability may be worth the risk when the result of the gamble is big enough if it succeeds, but anybody doing so must admit that it *is* a gamble, involving risks bigger than the scientist is justified in giving his blessing to—even though *he* also may sometimes be forced to take them. When therefore a difference is stated by the scientist to be "significant", remember that it does not mean that it *must* be a real and not a chance difference but only that the risk of its

being a chance difference is so small as to be fairly safely accepted. Similarly when the result is said to be "not significant", it does not mean that it cannot possibly be real, but only that the risk if its being only a chance difference is too big for safety.

When Single-Plot Experiments May Have Some Value

It was mentioned earlier in this paper that if the difference was big enough, even "single-plot" experiments can be relied upon. Thus if the yield of one plot is double that of the control, the odds are pretty high that this is chiefly the effect of the treatment, but if the difference is only 10 or 20 per cent, the odds are perhaps 5 or 10 to 1 *against* its being due to anything except chance.

There are two other factors which may greatly reduce the uncertainty of the results from single plots. The first of these is the *time factor*. If single plots have been carried on for a number of years, with careful recording of yields all the time, it may be possible by studying the relative behaviour of the plots during that time, to find differences in trend; the yield of one plot may have gone steadily up and that of another steadily down. Statistical analysis of such results is possible, and may often yield results of fair reliability. There is in fact replication here, though it is replication in time, not in space. But we do not want to wait for years to get definite results, if we can possibly avoid it, so whilst this is some consolation to those who have records of single-plot experiments started some years ago, it is no recommendation, and is not intended to be, that single-plot experiments should be laid down now.

The other factor is the *personal factor*. The planter who knows his rubber well can often see effects which have not or cannot be accurately recorded. It may not need more than a single plot to enable, e.g. the effect of manures on foliage and canopy to be clearly seen. If an area in which the trees had small sickly-coloured leaves, thin canopy and obvious "stag heads" and die-back, develops in a thick dark green canopy of large well-formed leaves, with lots of new growth in a few months after manuring, so that its improved condition leaps to the eye in comparison with the area not manured, then it would be sheer nonsense to deny, because only a single plot had been used, that the improvement was practically certainly caused by the manuring. Less spectacular differences in bark condition may also be detected with reasonable certainty by the man who knows his trees well. Should such improvements later be paralleled by the recording of a higher yield from the manured plot, then it is more likely that this is an effect of the manuring, even if it cannot be taken as sufficiently probable to satisfy the statistician.

We must remember that the statistician is the servant, not the master, of the experimenter, in much the same way that the architect is the servant, not the master, of the owner of a building. We expect the architect to design for us a building which is safe, and suitable for the use to which it is intended to be put, and so long as the building is properly constructed to that design, he takes the responsibility for its safety and suitability; but if we ask for a design for a dwelling house and he submits one more suitable for a block of offices, we do not have to accept it; whilst if he submits alternative designs, it is for us and not for him to decide which shall be accepted. We are perfectly at liberty to erect a building without any design or advice from an architect (that is, assuming we are outside

the jurisdiction of the municipal authorities!) provided we do so on our responsibility and do not ask him to accept any.

In just the same way, the experimenter is obviously quite at liberty to carry out "single-plot" experiments, and to draw his own conclusions from them, perhaps merely because he has a "hunch" that the result is so and so, or because he knows from his own observation that there have been effects which could not be recorded in figures, so long as he does not expect the statistician to take any responsibility for them, and so long as he does not expect others blindly to accept his conclusions. The rigorous mathematical tests which the statistician applies, on the other hand, serve as a guarantee which others can readily accept, and so they enable experimental results to be of use to the whole body of planters. But such tests can be validly applied *only* if the experiment is properly laid out in the manner already exemplified.

Variation between Localities. Field Experiments and Soil Surveys

It goes without saying that the results of an experiment in one locality cannot be unreservedly applied to another where conditions of soil, climate, trees, etc., are different. Due allowance must always be made, if it can, for such differences and it is here that the close relation between soil survey and field experiments is of such importance. The two should always go hand in hand, for when the soils of a country have been properly mapped as the result of a soil survey, it is possible to decide how far results obtained from experiments on a given type of soil are applicable in other places, according as the soils in those other places resemble or differ from that of the locality where the experiment was carried out.

Until such knowledge of soils is available as a result of a soil survey, advice on rubber cultivation in localities where the soil has not been examined and experimented on must always be of less sureness. The scheme of experimental planting under the aegis of the Rubber Research Institute, along with the soil survey work which is being done, is for that reason of the utmost importance, and may be expected to yield results of the greatest value to the rubber-growing industry of Malaya in due course.

Logical Selection of Problems

There is another aspect of field experiments with rubber: that of the choice of treatments in the scheme of the experiment. This refers more particularly to manuring experiments. There is sometimes a tendency to jump ahead to the study of matters of secondary importance before those of over-ruling primary importance have been elucidated. Thus experiments have sometimes been laid down to test, for instance, which form of phosphatic manure is best—say rock-phosphate or super-phosphate—or what is the most effective amount to use—before it has been found out whether on the soil in question there is need for any phosphate at all. The first essential question is, does the use of nitrogen, or of phosphate, or of potash, produce any result. Only if any one or more of these is beneficial, is it worth while comparing the relative merits of different forms of nitrogenous, or phosphatic or potassic manures as the case may be, or the relative effects of small and larger dressings and so on.

At the same time, in view of the relatively long time which must elapse in experiments with rubber trees before results of reasonable certainty are obtained, it is only natural that one should wish to avoid having to tackle the problems only in this logical order one after the other. An important recent

advance in the design of experiments is one which enables many of these different questions to be answered together by an experimental layout which is not much more complicated than that which is needed to answer only one set of problems at a time. Such an experiment has the further advantage that it may supply important information on what is known as the "interaction" of factors.

No attempt will be made here to explain in detail what is meant by this "interaction", but the kind of thing it covers is well enough illustrated by the following example. A soil might be so very deficient in phosphate that plants could not make more than very poor growth on that account, and so long as no phosphatic manure was given, nitrogen manures had little or no effect. The use of phosphatic manures would have a marked effect, but the much improved growth or yield thus resulting might *then* be prevented from being still better because the soil was not too well supplied naturally with nitrogen. The use of a nitrogenous manure along with phosphate would then produce a pronounced effect, additional to that produced by phosphate alone. That would be called a nitrogen-phosphate interaction, for the effectiveness of the nitrogen was subject to the presence or absence of phosphate. Nitrogen and phosphate together then give a bigger effect than the sum of the effects either gives in the absence of the other.

Practical Aspects of Field Experiments with Rubber Trees

It is not possible to deal here with certain special aspects on the practical side of the conduct of experiments on rubber, such as the size and shape of plots, the effect of individual variations between tappers, the effect of the average tapping height, avoidance of interference or "poaching" between adjacent plots, and so on. There is however one important aspect to mention. Hitherto it has been customary to use plots consisting of whole tasks or at most half-tasks, owing to the difficulty of organizing the tapping of smaller units without great uncertainty as to the reliability of the results. However, even when the results are obtained in the form of the yield of dry rubber from normal-sized tasks, it is often impossible on estates to supervise the collection and carrying-in of the latex by the coolies well enough to be reasonably sure that there has been no levelling-up of the amount of latex from different tasks. Such levelling-up will, of course, tend to vitiate the results of the whole experiment.

Another service which statisticians have done to field experimentation is the study and development of sampling methods for determining the yield of plots, instead of weighing the whole produce from them. Such methods should be particularly applicable to, and valuable for, experiments with rubber trees, when the annual yield of a given task is made up of perhaps 250 individual tree-tappings on each of say 150 days, or 37,500 separate samples. Work is now being done at the Institute on this subject, and also by Dr. Haines of Dunlop Plantations Ltd.

It may be expected that by collecting the latex separately from only perhaps one tree in every ten, on perhaps only one or two days a month, or less, considerably more accurate results from experiments will be obtained. Moreover, such a method would have the further advantage that individual plots in an experiment need no longer be as big as tasks or even half-tasks. Subject to their not being so small as to introduce extra troubles from individual tree-variation, they can be any size desired. For budded rubber in particular, where the uniformity

from tree to tree is much higher than with seedlings, very considerable reduction in the size of plots may be possible.

Conclusion

In spite of some digression from the original theme of the reason why the modern type of layout of field experiment is necessary, and how the statistician's services can be of enormous value to field experimentation with rubber, it is hoped that it has been convincingly demonstrated that the old idea of "single-plot" experiments, which still dies hard with many planters, is really of very little use. As to *how* the modern type of experiment —Randomized Blocks, Latin Square and the more complex type I mentioned a short time ago—do what they have been stated to do, this is a matter which can be properly explained only in terms of rather abstruse mathematics, and in this place it must suffice to refer to the notes and explanation appended to the examples above.

In conclusion, it is apt to cite the words of Robert Boyle, written in 1673, under the title of "Concerning the Unsuccessfulness of Experiments" as quoted by R. A. Fisher at the commencement of his book on "The Design of Field Experiments":—

> "I am very sorry, Pyrophilus, that to the many (elsewhere enumerated) difficulties which you may meet with, and must therefore surmount, in the serious and effectual prosecution of experimental philosophy, I must add one discouragement more, which will perhaps as much surprise as dishearten you; and it is, that besides that you will find (as we elsewhere mention) many of the experiments published by authors, or related to you by the persons you converse with, false and unsuccessful (besides this, I say), you will meet with several observations and experiments which, though communicated for true by candid authors or undistrusted eye-witnesses, or perhaps recommended by your own experience may, upon further trial, disappoint your expectation, either not at all succeeding constantly or at least varying much from what you expected."

Notes on Animal Diseases

Compiled by the Department of Veterinary Services, Kenya

I—REDWATER & ANAPLASMOSIS

Redwater

Redwater is a tick-borne disease generally distributed throughout East Africa. On farms where dipping is not practised, every calf contracts the disease on the average 15 days from birth. Where dipping has reduced the tick population to a low figure, however, cattle may escape infection during calfhood, and severe losses may occur if they are moved to a farm where infected ticks still occur.

Cause.—Several species of related protozoon parasites which produce redwater in cattle are known from different parts of the world, but only one, *Babesia bigemina,* occurs in Kenya. Although there may be some difference in virulence among different strains, there is no evidence to suggest that more than one immunologic strain occurs in Africa.

The parasites may be seen in blood smears. They invade and multiply in the red cells. Attacked cells are broken down in the body, and the red pigment of the cells (hæmoglobin) is liberated. Part of this pigment is converted by the liver into bile pigment, excess of which in the tissues causes jaundice, and part is excreted by the kidneys, giving rise to the characteristic symptom, hæmoglobinuria, from which the disease takes its name "redwater".

Incubation Period.—Following natural infection from the bites of ticks, the incubation period is 8 to 17 days. After the inoculation of blood, as during immunization with the so-called "vaccine", the reaction begins in 5 to 15 days, usually about the tenth day.

Symptoms.—The first sign of infection is usually a rise in temperature. The temperature may go to 105° F. or higher. If the animal is untreated the temperature remains elevated for several days, after which it returns slowly to normal or, in fatal cases, may fall suddenly to below normal a short time before death.

In the early stages there is dullness and a staring coat, and in severe cases there is marked disinclination to feed. During the later stages œdema of the lungs may cause distressed respiration. Nervous symptoms are not uncommon, being restricted usually to an unsteady gait; but occasionally signs of frenzy appear, the animal having uneasy, staring eyes and being liable to charge anyone approaching it. Depending on the rapidity of destruction of the blood cells, a reddish coloration, varying from pale red to deep claret, of the urine may be observed early in the course of the disease, or may be postponed until the fifth or sixth day of the temperature reaction. Examination of the eyes and the visible mucous membranes may reveal the existence of jaundice.

Post-mortem Appearances. — The blood appears thin and watery, the serum usually being tinged red. The loose tissue beneath the skin, the outer coats of the stomach and intestines and the whites of the eyes are often tinted a golden-yellow. The muscles may be pale and flabby.

In acute cases there is often œdema of the lungs and froth in the air passages and at the nostrils. The interlobular tissues of the lungs are then infiltrated with a yellowish fluid, causing the surface of these organs to appear to possess yellow veins. The heart-sac may contain an excess of fluid, often yellowish in colour. The heart itself usually shows

hæmorrhages on its surface and in the lining membranes of the cavities. There may be a yellowish gelatinous infiltration around the base of the heart.

The spleen is always considerably enlarged, its pulp being soft and dark in colour. The liver is enlarged and congested; usually it has a bright orange colour on section. The gall-bladder is distended and the bile thick in consistency. The capsules of the kidneys may be infiltrated with a gelatinous exudate. The kidneys, in acute cases, are congested.

The mucous membrane of the fourth stomach is claret-coloured and shows hæmorrhages on its surface. Stripes and patches of congestion and hæmorrhagic spots may be present in the intestines. The urine in the bladder is port-wine or dark-brown in colour.

Differential Diagnosis. — Redwater may be confused with several diseases, only three of which will be discussed here.

Cases occurring in adult cattle, not under close observation, may from a report of sudden death, and from the large size of the spleen seen at post-mortem examination, be confused with anthrax. The appearance of the blood is usually sufficient to distinguish anthrax from redwater, for in the former disease it is very dark, often black in colour, and tarry in consistence.

The stiff gait observed in redwater is not infrequently mistaken for a symptom of heartwater. Redwater cases showing stiffness, however, have almost always reached the stage at which the urine is characteristically coloured.

Finally, the appearance of the urine in redwater is due to pigment only. This appearance must not be confused with the presence of actual blood and blood clots in the urine, a symptom characteristic of enzootic hæmaturia. This latter is a chronic disease, usually found in cows and work oxen, which appears to be restricted to certain parts of the Limuru, Kericho, and Hoey's Bridge districts, and is almost certainly a nutritional disorder.

When submitting smears for confirmation of diagnosis, smears taken from the ear vein should always be sent. Blood is always present in the spleen, but it is often difficult to detect parasites in a spleen smear.

Transmission.—The most important vecting tick in Kenya is *Boophilus annulatus* var. *decoloratus,* the common blue tick. This tick is a one-host tick; that is to say, it spends its whole life on one animal, not dropping to the ground to moult between the larval and nymphal or between the nymphal and adult stages. The engorged females drop to lay their eggs and the larvæ that hatch obtain a host in the usual way. For such a tick to transmit a parasite from one host to another it is of course obvious that the infection must pass through the egg. Infection has also been shown to pass through the egg in the case of a two-host tick, *Rhipicephalus bursa.* With *Boophilus annulatus* it has been proved that, once a batch of ticks is infected, several generations may be passed on insusceptible animals without the infection being lost, and with *Rhipicephalus bursa* that the feeding of the larval-nymphal stage of infected ticks on a horse failed to render them, after moulting to adults, non-infective for susceptible cattle.

Less effective transmitters are *Rhipicephalus appendiculatus*, the brown tick, and *R. evertsi*, in neither of which has it been possible to demonstrate the transmission of infection through the egg.

While definite information on the point appears to be lacking, it is probable that,

as in the case of tick fever in the dog and East Coast fever in cattle, a tick is not able to infect cattle with redwater until it has been feeding for three to four days.

Treatment.—A number of drugs are available which have a specific lethal action on the parasite. The most valuable of these are trypanblue and acaprin (akiron-R).

Trypanblue for the treatment of redwater is issued by the Laboratory at Kabete in tubes containing one maximum dose. The contents of the tube are dissolved in about 200 c.c. of clean boiling water and then the solution is allowed to cool. When quite cold the solution is filtered through blotting paper or filter paper. It is essential that the solution be allowed to cool properly, or some of the drug may come out of solution after filtration, and in the solid state it is very irritating to the tissues.

An average subcutaneous dose of the solution for an adult animal is 120 to 160 c.c. The solution may be inoculated either subcutaneously or intravenously. Unless the operator has had considerable experience of the intravenous method, the former is recommended. For preference the solution should be warmed to blood heat before inoculation, divided and inoculated at four different sites; for example, one in front of and one behind each shoulder. Needless to remark, the syringe and needles should be sterilized by boiling before use and the sites of inoculation cleansed with a solution of some disinfectant.

Should a swelling develop at any of the sites it should not be opened unless it points. Swellings often form that are not the result of bacterial infection, and if fomented daily with warm water they will disappear without bursting.

Acaprin (a Bayer product) is not issued by the Laboratory, but may be obtained from Messrs. Hansing & Co., Nairobi and Mombasa. It is issued as a 5 per cent solution ready for use. The dose is 1 c.c. per 120 lb. bodyweight, and it is advisable to adjust the dose accurately. This drug is undoubtedly less troublesome to use than trypanblue and, from reports received, it appears to be very effective.

Preventive Measures.—The preventive measures against redwater are dipping and protective inoculation. As dipping is used similarly against anaplasmosis and inoculation against the two diseases is usually combined, discussion is postponed until the latter disease has been described.

Anaplasmosis (True Gallsickness)

This disease occurs on all farms where redwater is present. Where dipping is not carried out, calves go through anaplasmosis during the third month of life. Imported European cattle, and a percentage of cattle from farms where dipping from birth is practised, are highly susceptible.

Cause. — Anaplasmosis is due to a microscopic parasite which invades the red blood cells. In blood smears the parasites are seen as a black dot occurring on the margin or the centre of the cells. In the former case the parasite is *Anaplasma marginale* and in the latter *A. centrale.* As the parasites are very small and show no characteristic internal structures, care should always be taken that good clean blood smears are submitted for diagnosis. It is not always possible to give a definite diagnosis from spleen smears.

It is the exception to find *A. centrale* in cases infected naturally. A strain of this parasite, which produces a milder form of the disease, is used in the immunization procedure.

In calves reared under ranching methods anaplasmosis is a very mild disease. Calves that are hand reared are

somewhat more susceptible, although in these also, provided that they are properly fed and are free from complicating diseases such as paratyphoid, the reaction should be so slight as to pass unnoticed.

The term "gallsickness" is used loosely to cover a variety of conditions, mainly digestive disorders.

Symptoms.—The symptoms in many respects resemble those of redwater, except that red urine is not passed. The first indication of infection is a rise in temperature, usually gradual, but sometimes rather sudden. The animal appears dull, there is a staring coat and disinclination to feed. Constipation is usually marked, but in the later stages diarrhoea may supervene. As in redwater, œdema of the lungs may occur.

During the acute stage the skin and visible mucous membrane may have a yellowish colour. When this stage has passed it is usual to find marked anæmia, manifest in a paleness of the eyes, lips, gums, and of the vulva in female stock. The tongue is usually notably white.

Death may occur in the acute stage, but some of the animals that survive this die later of anæmia and cachexia.

Post-mortem Appearances.—The characteristic appearance is that of a jaundiced condition of the tissues. In protracted cases the carcass is emaciated, the flesh pale and the blood pale and watery.

The lungs are sometimes œdematous, a frothy fluid exuding from the surface when cut. Froth may be present in the wind-pipe. The chest cavity and heart-sac may contain an excess of yellowish fluid. The heart may show patches of small hæmorrhages on the surface and either patches or stripes of hæmorrhages on the linings of the cavities.

The liver is enlarged and usually yellowish-brown in colour. The gall-bladder is distended with thickened yellow or orange bile. The kidneys may be congested. Usually they are stained yellow. The urine is pale.

The spleen is often enlarged and the pulp soft in consistence. In animals that die several days after the acute symptoms have subsided this organ may appear thin and shrunken. Lesions in the fourth stomach and intestines vary in intensity. The fourth stomach may show hæmorrhagic points and the intestines contain a quantity of mucous; in some instances acute inflammation of these organs is present.

The lymphatic glands are usually enlarged and flabby.

In chronic cases and in calves diagnosis may be impossible from an examination of the carcass, which may reveal little except cachexia and a pale watery condition of the tissues in general.

Transmission.—As with redwater, the most important East African transmitting tick is *Boophilus annulatus* var. *decoloratus*. Members of many other tick genera (*Amblyomma, Hyalomma, Dermacentor, Ixodes* and *Rhipicephalus*) can transmit anaplasmosis, but hereditary transmission has only been proved in some varieties of *Boophilus annulatus, Rhipicephalus simus,* and a tick that does not occur in East Africa, *Ixodes ricinus*. It is very doubtful if infection through the egg ever takes place in *Rhipicephalus bursa* and *R. appendiculatus*.

In America outbreaks of anaplasmosis have been attributed to direct transfer of blood from animal to animal during the operation of dehorning and while bleeding cattle for contagious abortion agglutination tests. Biting flies of the genus *Tabanus* have also been blamed for mechanical transmission.

Treatment.—Unfortunately, no drugs of efficacy comparable to that of trypan-blue in redwater are available for the treatment of anaplasmosis. Some authors have reported good results from the use of trypaflavine, 25 to 100 c.c. of a 1 per cent solution being administered intravenously; while others have failed to demonstrate that this drug exerts any useful action. The larger dose has a very small margin of safety.

Another drug that has been recommended is mercurochrome-220. The dose of this drug is 0.4 grm. for calves and a maximum of 1.3 grm. for adults. The drug is administered intravenously as a 2 per cent solution in normal saline.

Symptomatic treatment and careful nursing are of considerable value. The animal should be placed in a comfortable dry stable and given green fodder and good hay. Sloppy mashes with the addition of molasses help to provoke thirst and to prevent constipation. Any tendency to constipation should be corrected by a dose of linseed or salts with 25 to 35 grains of calomel. If the animal appears depressed or refuses food, stimulants such as ammonium carbonate and nux vomica should be given two or three times daily.

Dipping as a Preventive Measure against Redwater and Anaplasmosis.—The obvious method of preventing the occurrence of redwater and anaplasmosis is to eliminate the transmitting ticks by dipping. By reducing the number of ticks, other tick-borne diseases such as East Coast fever and heartwater are also controlled, and there is little doubt that a cattle dip is one of the first essentials for a farm where stock are to be kept.

One-host ticks, such as *Boophilus annulatus* var. *decoloratus,* which remain attached to the one animal for a period of three to four weeks, are the easiest to control by dipping and may be destroyed by dipping at intervals of 3, 5, 7 or 14 days. To prevent brown ticks from dropping engorged from recovered redwater gallsickness cattle, dipping at intervals of 3 or 5 days should be combined with hand dressing. The larval and nymphal stage of *R. evertsi,* the red-legged tick, remains on the host for ten days, hence dipping within this period will effect its destruction.

Larval blue ticks can live for about eight months without a host. If a farm is well stocked and dipping regularly carried out in a dip kept up to proper strength, the majority of blue ticks on the grazing should be killed in about eight months.

Dipping, even at intervals of 7 or 14 days, by killing off the majority of blue ticks soon results in a percentage of cattle reaching maturity without having passed through an attack of redwater and anaplasmosis. Short-interval dipping combined with thorough hand-dressing results in this stage being reached earlier. Mortality from these diseases in adult cattle may now occur. It is the practice on many farms to leave the calves undipped until several months old in the hope that they will become infected and lose their susceptibility. This practice is most unsatisfactory, for it prolongs the low-tick-infestation period indefinitely. There is little point in taking vigorous steps to eradicate ticks on adult cattle and at the same time breeding them on the calves. The eventual goal is presumably the complete eradication of ticks from the farm, and every step should be taken to attain this end as soon as possible. During the transition period calves may be given a dose of redwater-anaplasmosis blood which will ensure, with much more certainty than if infection had been left to ticks, that they become infected with these diseases, and in a reasonably short time the danger period will be over.

Immunity in Redwater and Anaplasmosis.—Animals that have recovered from redwater and anaplasmosis infection continue to harbour the parasites in their blood for varying periods of time. In redwater, infection has been known to persist for from twelve months to twelve years after removal from any possible source of reinfection. In such animals parasites cannot be found on microscopical examination of the blood; but although to all appearances they are in perfect health, their blood, on inoculation to susceptible cattle, will transmit the diseases.

Reinoculation of recovered cattle with redwater and anaplasmosis will not cause any noticeable reaction. However, if a large dose of multiplying redwater parasites is given, parasites may be detectable in the blood again for a few days. Therefore although they are immune the condition of recovered redwater-anaplasmosis animals differs from that of animals that have recovered from a disease like rinderpest, from which the virus cannot be recovered, and the name "premunity" is now used for the former condition. Animals in the premunized state may show relapses when attacked by another disease, such as East Coast fever, or when exposed to such detrimental influences as long railway journeys or marked changes in altitude.

Inoculation of Cattle against Redwater and Anaplasmosis.—The system of preventive inoculation against redwater consists in inoculating blood from a recovered redwater animal so that a reaction to the disease occurs while the inoculated animal is under close observation. Actually inoculation of blood containing the parasites of redwater usually results in a milder reaction than when infection is contracted from the bite of a tick. By taking the temperature each morning and evening throughout the time that the reaction is to be expected the first sign of infection is detected. If the temperature goes above 104° F., or the animal refuses to eat, a proper dose of trypanblue or acaprin should be given.

Protection against anaplasmosis is effected by two inoculations. The first inoculation is with the blood of an animal harbouring *A. centrale,* which produces a milder reaction than the wild *A. marginale* and gives a certain amount of protection against the latter parasite. The second inoculation is given when the first reaction is over and the animal's health has returned to normal.

Cattle undergoing inoculation must be kept under tick-free conditions, at least until the reactions to redwater and *A. centrale* are over. The ground around the stable in which they are kept should be cleared of grass for a distance of ten feet and should be kept clean. The cattle should be exercised on a piece of hard ground free from grass. Fodder and other foodstuffs should be free from ticks.

When inoculating imported cattle the usual procedure is first to inoculate pure *A. centrale* blood. The period between the inoculation of the blood and the first signs of the reaction varies from 30 to 50 days, and the animal has thus about a month to become acclimatized to East African conditions. The duration of the reaction is from 4 to 40 days. Slides should be submitted to a veterinary officer or to the laboratory during the time that the reaction is to be expected, every other day, until a confirmation of the presence of the parasite is received. Slides should then be sent at weekly intervals so that the state of the animal's blood can be followed and the time when it will be considered safe to inoculate the second vaccine can be judged. If

necessary, symptomatic treatment should be given.

When the animal has recovered from the *A. centrale* reaction, blood containing redwater and *A. marginale* is inoculated. The reaction to redwater begins from 5 to 15 days after inoculation. Slides should be submitted daily during this period until a diagnosis of redwater is received. If necessary—that is, if the temperature rises above 104° F. or the animal refuses food—treatment should be given. The reaction to *A. marginale* occurs 30 to 50 days after the blood has been inoculated, and slides are taken and treatment given, if necessary, as in the case of the *A. centrale* reaction. In all cases when submitting smears the date of inoculation and type of vaccine, together with the animal's temperature, should be stated on the slide folder. In addition to slides at the stated periods, slides should be sent for examination at any time that the animal's temperature shows an abnormal rise.

When inoculating cattle purchased locally it is advisable to inoculate redwater along with the first *A. centrale* vaccine. The question of acclimatization does not arise, and the sooner the reaction to redwater is over the better, as danger of a chance reaction from infection by a stray tick is reduced. The reaction to redwater is then awaited at the usual time, but after the first inoculation. Otherwise the procedure is the same.

Generally speaking, the inoculation of in-calf cows and heifers is not recommended. During the early months of pregnancy the procedure is usually free from risk of abortion, but the advice of a veterinary officer should be obtained when such inoculations are contemplated.

Young calves, if properly fed and in good health, may be inoculated with redwater and *A. marginale* and left without further special attention. The reactions should be so mild as to pass unnoticed.

It should be remembered that the vaccine is not a vaccine in the true sense of the term. It will not prevent the condition known as anaplasmosis in calves. For this condition to occur in calves, the vitality of the calf must be lowered by some other factor, and this factor is just as likely to provoke a severe reaction to the vaccine as during the course of infection naturally contracted from ticks. To control anaplasmosis in young calves, attention should be given to feeding, housing, and to the elimination of paratyphoid, bacillary necrosis and other calf diseases.

(Other diseases will be dealt with in later issues.)

Two Levelling Instruments

By F. B. WADE, *B.Sc., M.Inst.M.M., Chief Geologist, and* A. CAWLEY, B.Sc., *A.R.S.M., Geological Division, Tanganyika Territory*

I—STRIDING LEVEL FOR CONTOUR RIDGING

Construction

The main member consists of a piece of seasoned board 10 ft. long by 6 in. wide by 1 in. in thickness. It is mounted on legs made of similar material 2 ft. 6 in. long. These are securely screwed to the ends of the main member as shown in Fig. 1.

At the centre of the main member a small builder's spirit level is secured to the upper edge of the plank by means of two wood screws. Between the level and the plank a thin strip of soft rubber should be laid. The purpose of this is to enable final adjustments to the level to be made when calibrating the completed instrument.

Calibration

The instrument should be set upright on its legs upon a reasonably level concrete floor. The floor should be marked with chalk where the legs take their stand. Next, the bubble in the level should be observed, and if it is not at rest centrally one of the securing screws should be tightened until the bubble travels towards the centre-line of the level. The screw should be tightened until the bubble has travelled half the distance it was in error.

Now turn the instrument about, interchanging the positions of the feet upon the previously made chalk marks. Adjust the error of the bubble by tightening the screw that will bring the bubble near the centre-line. Again the bubble should be brought only half the distance towards the centre-line.

This calibration should proceed, turn and turn about, until the bubble remains centrally disposed in either position of the feet.

Use of the Instrument in the Field

In general, contouring should start near the divides between watersheds; consequently before starting, these divides should be previously determined. If, however, the area to be contoured is restricted by boundary fences, care should be taken to prevent surface storm water from entering the field from beyond the confining boundaries.

Starting at the upper boundary, the instrument is set upright on the cleared surface of the field, and while one leg of the instrument is kept in contact with the ground the other is moved round on the arc of a circle until a position is found where, with both legs resting on the ground, the bubble will lie centrally in the level.

Now swing the instrument round pivoting on the leg nearest to the direction in which it is desired to traverse, and repeat the process already described. The position previously occupied by the other legs should now be marked by a labourer by digging up a sod with a hoe. By continuing in this way a line of upturned sods 10 ft. apart will demarcate the trace of the contour desired.

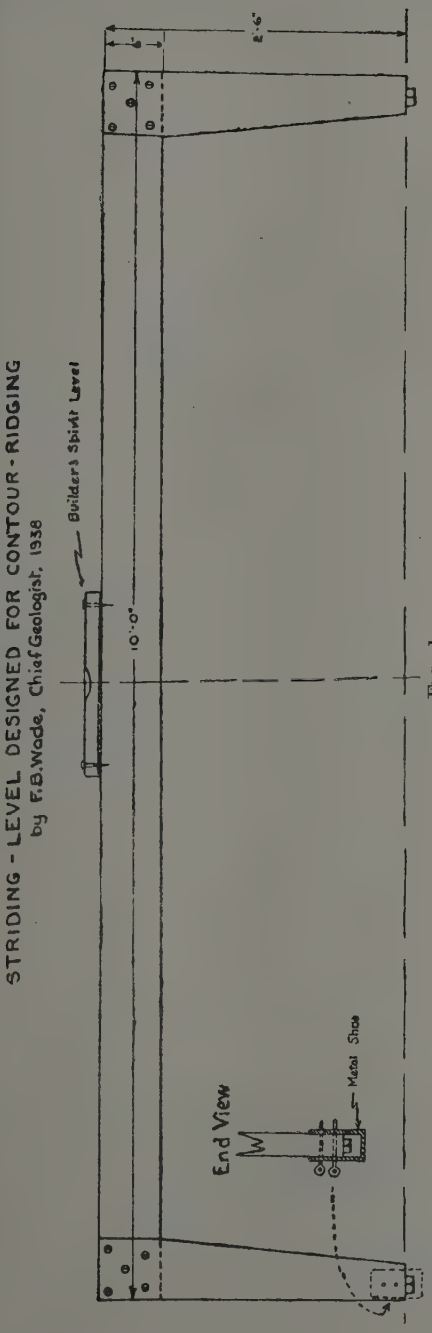


Fig. 1

II—Frame for Levelling

Construct the frame of seasoned timber according to the dimensions shown in Fig. 2, and secure the plumb-line to a wood screw inserted at the centre of the top overlap.

Set up the frame on an approximately level surface on which the positions of the feet of the frame should be marked. Then with a pencil mark the position of the plumb-line on the cross member. Reverse the frame on the marked feet positions and again mark the position of the plumb-line on the cross member. Bisect the two marks on the cross member to obtain the true level position of the plumb-line, and from this point mark off calibrations as indicated in enlarged section of cross member on the diagram. The calibrations can be marked by drilling small holes in the cross member.

With the frame in position from level up to a gradient of 1 in 1, the gradient can be observed by noting the position of the plumb-line and interpolating between the calibrations if necessary.

The size of frame indicated in the diagram will be sufficient for work of moderate accuracy, but should a higher degree of accuracy become necessary then the dimensions can be increased in proportion.

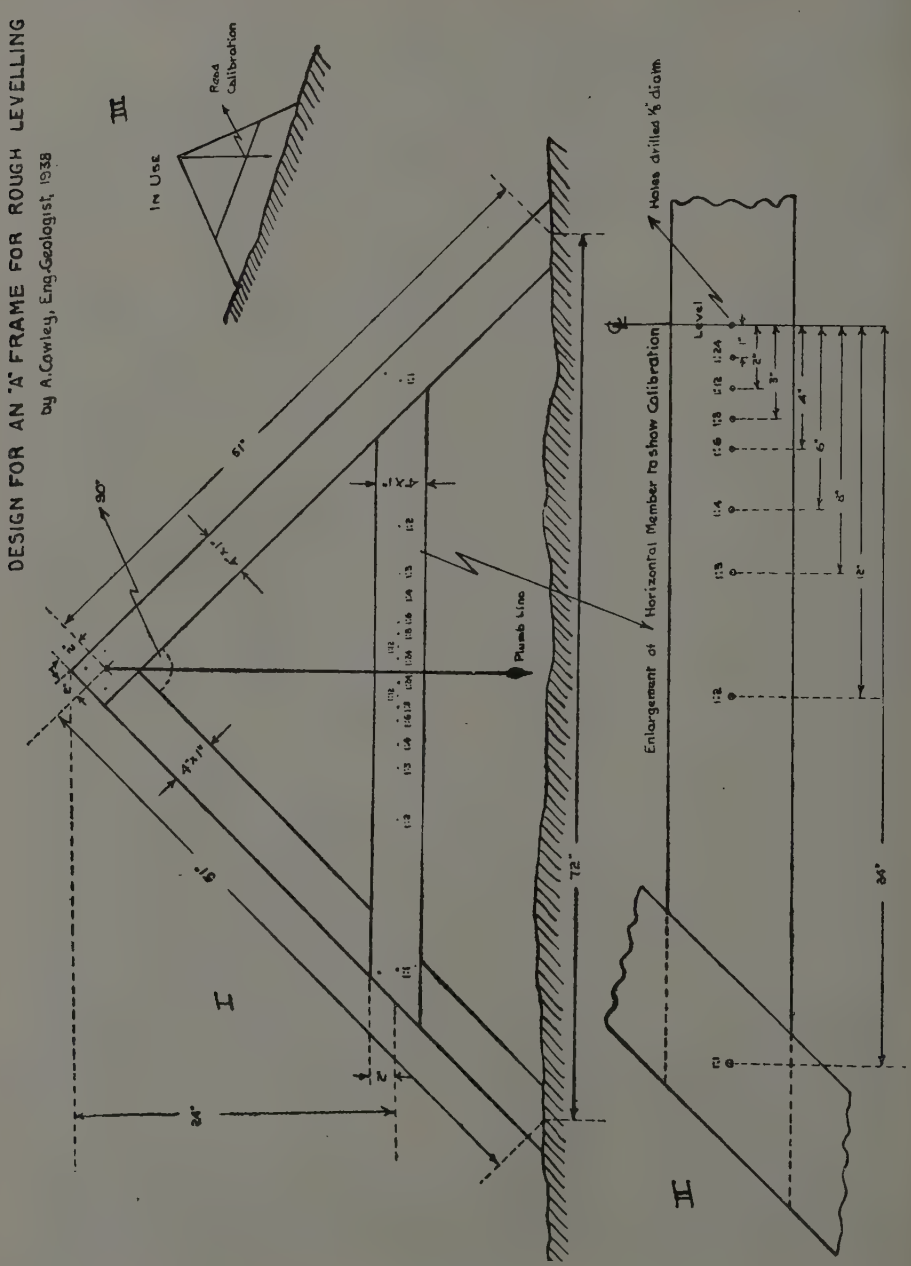

DESIGN FOR AN 'A' FRAME FOR ROUGH LEVELLING
by A.Cowley, Eng.Geologist, 1938
III
In Use
Road Calibration
Holes drilled ¼" diam
Level
Enlargement of Horizontal Member to show Calibration
Plumb Line
90°
61"
72"
24"
I
II

FIG. 2

Soya Bean Bread: A Recipe for the Home Baker

By M. HALCROW, *Agricultural Officer, Kenya*

The soya bean has been a staple food in the east for centuries, but only recently has it come to be known as a useful food product to the white civilization of the west.

The soya bean is rich in body-building materials, protein and oil, and naturally, with the advent of "Keep Fit" movements and the like, it was not long in coming under the notice of experts on dietetics and nutrition. As a result, many and varied recipes have been produced to include the soya bean. In the opinion of the writer, however, there is no simpler and more effective way of taking advantage of the soya bean's high food value than in the daily bread. Ordinary white flour is deficient in protein or body-building material and roughage; consequently, the use of a proportion of soya bean and whole meal flour in the bread mixture is calculated to give a product with a more balanced ratio of protein to starch and, in fact, a nearly perfect food. Using a small coffee grinder to mill the soya beans and the whole wheat, the writer has produced a most attractive and appetizing loaf according to the recipe given below.

Materials required—

Soya bean flour (all-yellow variety is best),
Wholemeal flour,
White flour,
Whole milk,
Sugar, salt and yeast.

First make ready the yeast as follows: To half pint of warm milk (blood heat) add one level teaspoonful "Florylin" yeast and two teaspoonfuls sugar. Stir well and allow to stand for 20 minutes. Now take half a cup of soya flour, one cup of wholemeal flour, two cups of white flour, mix well and make into a dough by adding the milk and yeast, which must be well beaten up before use. Add more warm milk if necessary. Leave in the mixing bowl in a warm place for 20 to 30 minutes. Add salt to taste and knead well, adding white flour as required. Place in a well-greased tin and stand it on side of the stove for three-quarters to one hour till well risen. Bake in a suitable oven till ready. The use of whole milk adds greatly to the food value and the keeping quality.

It will be seen that the entire task of making this delightful bread takes only 2½ to 3 hours. The times stated in the recipe were arrived at after many experiments in the use of preserved yeast in making both white and brown bread. It was found that disappointing results in breadmaking were frequently due to over-rising in the bowl and that the tedious business of putting bread down at night and baking in the morning, or vice versa, could be obviated quite easily.

Soya bean bread made as above is manifestly an ideal food for children, since it contains protein, starch and roughage in a better balanced proportion than is found in ordinary bread, either white or brown. At the same time, soya bean bread, either toasted or plain, is extremely palatable, and the writer heartily recommends its use for parents and children alike.

Coffee Selection in the Netherlands Indies*

By DR. C. J. J. VAN HALL

In the matter of selection of perennial crops, such as coffee, rubber, cacao, cinchona, kapok, tea, the initiative was taken and most of the pioneer work has been done in the Netherlands Indies.

Selection of coffee was started some twenty-five years ago. Planters had indeed made a few feeble efforts before that time to improve their crops by selecting what they considered to be the best planting material, but their methods were inefficient and it was only after the Department of Agriculture and the Experimental Stations had taken the matter in hand and based selection on scientific principles that the work was carried on in a manner which promised satisfactory results.

The species mainly used in these selection experiments was *Coffea robusta,* which is the species most widely cultivated in the Indies at the present time. The once famous Arabian coffee (*Coffea arabica*) from Java, generally known to the trade as "Java coffee", has lost its commercial significance. During the 19th century it held first place as a product for export. About the middle of that century more than a million piculs (roughly 60,000 tons) was exported yearly. Then it fell a victim of coffee-leaf disease. This pest spread from East Africa all over Asia, devastating coffee plantations in Ceylon, where it appeared in 1867, and in Sumatra and Java, where it was first noted in 1876. No really practical means of controlling this disease has as yet been discovered. Planters simply had to abandon the cultivation of *arabica* and replant their fields with other crops. At present not more than some 7,000 tons of "Java coffee" are exported yearly and the greater part of this comes from native plantations.

Between 1880 and 1900 much was expected from Liberian coffee, which had been imported by the Government in 1876. But this species, though at first it seemed immune against leaf disease, also fell prey to this plague after a while, and gradually the fields became bare once more.

In 1900 another species, new to the Indies and so far unknown, was imported from West Africa and named *Coffea robusta.* It appeared to be much more resistant to leaf disease than the Arabian and the Liberian coffee, and it soon became popular on the estates as well as among native farmers. Larger and larger crops of it were cultivated year by year, until at present it constitutes a most important product, the estates, especially in Java, producing more than 55,000 tons yearly and the native farmers, particularly in Sumatra, about the same quantity. About one-third of this quantity is consumed locally and roughly 80,000 tons are exported.

Like so many of our tropical crops, this *C. robusta* is a heterogeneous mixture of a number of strains and any given plot will contain trees presenting widely divergent characteristics. For this very reason it may be regarded as an excellent object for experiments in selection.

This work has been taken up by the Bangelan Government Coffee Estate, the Central Java Experimental Station in collaboration with the Banaran Coffee

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Estate, the Malang Experimental Station,[1] and finally the Besuki Experimental Station at Djember.

The method first pursued on the Bangelan and Banaran Estates is generally called "mother tree selection." It may be briefly described as follows:—

(1) Selection of mother trees showing superior qualities.

(2) Propagation of these trees by vegetative reproduction (grafting) or by seed.

(3) Testing of the offspring, both grafts and seedlings.

The first mother trees were selected at Bangelan by Dr. P. J. S. Cramer in 1907 and at Banaran by Caesar Voûte in 1911. This work is less simple in the case of coffee than in that of other crops. The productivity of the mother tree is the first thing to be studied, but other qualities have to be considered as well, especially that of resistance to diseases and the size of the bean. Much painstaking and carefully supervised work has to be done before reliable information can be obtained regarding the productivity of the mother trees and the whole process has to be repeated, and the same difficulties faced, when the offspring of these mother trees have to be tested in their turn. The laboriousness of the work involved accounts for the fact that coffee selection has not become as popular with the planters as has, for instance, the selection of rubber. In the case of rubber the procedure can be combined with the ordinary work on the plantation without causing very much extra trouble, but this is not the case with coffee.

Seedlings as well as grafts were used in studying the progeny of these mother trees. Grafts present obvious advantages: In their case there is only a mother tree involved and no father tree. Hence the progeny are uniform, being absolutely identical with the mother plant, at least in their hereditary characteristics. It is this fact which has led to propagation by grafts or cuttings or buds—vegetative propagation, as it is called—being the method generally adopted in the cultivation of most of our fruit trees and many of our ornamental plants. To have the plants uniform is a great advantage on a coffee estate when it comes to picking; for this means that the difficulty of having early bearing trees interspersed with late bearing ones is avoided. Uniformity of the beans also makes preparation of the product for the market simpler. A further advantage of grafts is that, when we are obliged to deal with soils infected with eelworms (*nematodes*), they can be successfully grown on resistant seedlings as stock.

But grafts have also drawbacks. A coffee tree can produce only a very limited number of grafts per year and therefore propagation proceeds slowly. Then, the grafting technique complicates plantation work materially. Again, the stock may influence the qualities, and especially the yield of the graft, which makes the selection of the right stock a problem itself.

The above considerations led experimenters to conclude that for testing the progeny of selected mother trees it was advisable to make use of both the vegetative and the generative methods of propagation.

The first experimental plots of grafted trees—each plot containing only the grafts of a single mother tree and thus

[1] A few years ago the Central Java Experimental Station and the Malang Experimental Station were combined and became the Central and East Java Experimental Station.

representing a single clone[1] — were planted on the Banaran Estate in 1915 and at Bangelan in 1916. At Banaran there were thirty-two plots each carrying twenty-five trees. At Bangelan each plot had sixteen trees. In the course of time the number of selected mother trees at Bangelan has much increased and now there are more than 500 experimental plots of sixteen trees each under observation there.

As in the case of rubber, these experiments showed that only a few of the many trees selected for their high productivity produced offspring with a high yielding capacity. Many clones had to be discarded as not up to standard, or entirely worthless, and only a very small percentage was kept as being really superior.

When, for the purpose of further study, larger plots of these high yielding clones were planted, a remarkable and at first disappointing fact was observed: the yield per tree proved to be considerably less than that obtained from the smaller plots. The clue to the situation was found when the biology of the flower was studied and the fact emerged that most clones are better adapted to cross-pollination than to self-pollination; in other words, trees of one clone are, generally speaking, most productive when fertilized with pollen from trees belonging to another clone. Not all clones behave alike, however, in respect to this matter of pollination. Some produce practically no seeds at all when self-pollinated, others—the majority — produce a small or mediocre yield when self-pollinated, but show a much higher degree of productivity when cross-pollinated. A very few yield satisfactorily whether cross-fertilized or self-fertilized.[2]

The fact that almost all clones give a somewhat higher, or even a much higher yield when cross-pollinated has led planters to avoid planting large plots with a single clone. The general practice is to combine two or more clones which have yielded satisfactorily when inter-crossed. A great deal of laborious experimentation was required to find these combinations. But the work has now progressed to the point where we may say that the really fruitful combinations of our best clones have been determined.[3]

After the combinations had been determined another problem arose, namely, what is the best method of inter-planting? It was impossible to answer this question without first inquiring how pollen is carried from tree to tree under natural conditions. Until recently, no one knew what role insects and the wind played in the fertilization of these plants. But investigations made of late years have shown that in a coffee plantation the number of insects that could possibly play a part in the fertilization is so inconsiderable that it is safe to say without further investigation that pollination of our *robusta* does not take place through their agency. Remains, then, the wind, and it was J. P. Ferwerda's interesting experiments that taught us many facts regarding the details of the process. Glass plates were set up at different distances

[1] "Clone" stands for all the graft-descendants of one tree collectively.

[2] To quote an instance or two: self-fertilization produces poor results in clones R. Bgn (short for *robusta* Bangelan), 300, 325, and 340; mediocre results in R. Bgn. 83—03, 105—04, and 525, and satisfactory ones in the case of R. Bgn. 371 and 121.

[3] For example, the above-mentioned Bgn. 105—04, one of our most promising clones, yields successful results when pollinated with Bgn. 83—03, 300, and 325, or with *Quillou* Bgn. 121; Bgn. 300—also a very promising one—combines satisfactorily with Bgn. 105—04, 325 and 372.

from coffee trees in bloom and covered with some sticky substance. It was then discovered by the deposits on the glass that a moderate wind will carry the pollen as far as one hundred metres and raise it to a height of at least eight metres. The results thus obtained put the question of interplanting on a stable basis.[1]

As already mentioned, it is by no means a matter of indifference in the case of *C. robusta* what stock is used for grafting. Some twenty years ago, when selection work was still in its infancy, it was thought that *C. excelsa* was the ideal stock for *robusta* grafts. Later, preference was given to *robusta* itself as a stock. But it has now been proved that both species contain strains which make them suitable for use as stock for *robusta* clones. It has also become apparent that seedlings belonging to the same species as the scion do not by any means always produce the best results as stock.[2]

These results, obtained by much painstaking and difficult work in experimental gardens, are very encouraging, but we may not base direct conclusions on them as to the value of any given clone when planted on other estates. For experiment has shown that the behaviour of each clone varies with soil, climate and cultivation. For this reason the Experimental Stations always advise planters to make trial plots of more than one selected clone, for each planter has to find out for himself which clones produce the best results on his particular estate.

On the Banaran Estate selection work was carried on by Caesar Voûte, the manager of this estate, along the same lines as those pursued at Bangelan. But here there was no opportunity for research work, and the selection had to be done in accordance with the kind of routine which could be followed on other estates as well. Some promising clones were obtained, as for instance Banaran Nos. 4 and 7.

At Sumber Assin, the coffee garden of the Experimental Station at Malang, the selection was done by Dr. Hille Ris Lambers of the Central and East Java Experimental Station. Results obtained there corroborated the view obtained at Bangelan that most of the *C. robusta* trees or clones are "self-incompatible," i.e. give very little fruit when self-pollinated, and at this station as at Bangelan data were collected bearing on the problem of how to combine father and mother trees so as to obtain the most fruitful pollination.[2]

Very satisfactory results have also been obtained at the fourth institute which has taken up the selection work, namely, Besuki Station at Djember in the most easterly part of Java.[3]

Some private estates have begun to follow the example of the experimental stations, selecting a number of mother trees and planting plots of grafts from these for experiment and study. Mention should be made in this connexion of the Kalisanen Estate and the clones there

[1] Seedlings of clone Bgn. 124—01 are very good stock for most of our *robusta* clones. They have also proved to be good stock for *C. congensis, C. excelsa* and *liberica* × *arabica* hybrids. One of the *Quillou* clones, namely, *Quillou* Bgn. 121, also produces seedlings that are suitable for use as stock for most of the *robusta* clones. (*Quillou* may be considered a variety of *C. robusta*.) The same may be said of SA 109, a clone from the Experimental Garden "Sumber Assin," one of the *canephora* clones (Madagascar 3 Bgn.) and two *excelsa* clones (Bgn. 121—04 and 121—10). For some of the clones the yield figures obtained from the experimental plots are very satisfactory. At Bangelan, for instance, in some fields Bgn. 104—105, 300 and 124 gave about double, or almost double, the average yield of ordinary seedlings.

[2] We may note SA 13, 56 and 109 as high yielding clones obtained at Sumber Assin.

[3] Of the clones here obtained, BP 39, 42 and 56 deserve special mention.

grown, one of which seems particularly resistant to drought.

In the foregoing we have considered only the grafted offspring of mother trees, the clones. But it has been doubtful from the first whether "vegetative" propagation (by grafts in the case of coffee) or "generative" propogation (by seeds) would prove the more successful, and at both Bangelan and Banaran the two methods were tried. This "generative" selection has proved to be another very large field calling for laborious investigation.

During the first few years of selection work at Bangelan seeds were gathered from the mother trees without pollination having been controlled in any way. The offspring thus obtained was by an unknown father. At Banaran another method was followed. Here an effort was made to produce seeds by self-fertilization of the mother trees. The advantages of self-fertilization are obvious, namely, that in the case of seeds produced by this method the superior mother tree becomes also the superior father tree and the trouble involved in artificial crossing is avoided. In order to achieve this self-pollination, mother trees or branches thereof were put into cages made of mosquito-netting. The number of seeds obtained in this way was, generally speaking, small—very small indeed, in some cases. Since we have learned that many *robusta* trees yield only a small quantity of seed when self-pollinated, this result no longer surprises us.

It must not be supposed, however, that the quantitatively disappointing yield produced by self-fertilization necessarily involves seeds that will bring forth weakly or low-yielding trees. In a number of different cases "seedling families"[1] obtained by self-pollination have proved to be excellent and have, some of them, won excellent reputations among the planters. At Bangelan a number of such families were produced. These are not, like corresponding ones at Banaran, the descendants of single trees but of monoclone fields. Most of these fields are about two and a half acres in size, and hence the berries from trees in the middle of the plot are practically all the product of self-pollination.

Artificial crossing has been used to produce a large number of "families." These have been kept under observation, each on its own plot, exactly like the clones or grafted offspring. Of these also the majority had to be rejected, but a minority produced seedling families that excelled in yielding capacity or in some other respect, or occasionally in all respects. Some families were quite uniform, others very heterogeneous.

It is hardly necessary to say that the testing of the seedling families requires the same laborious care as the testing of the clones. Many different plots have to be kept under observation for a number of years before a reliable impression can be obtained about their productivity and other characteristics.[2]

In the foregoing only *C. robusta* has been dealt with and this species is indeed the one which has been mainly studied. But it not the only one to which scientists

[1] The word "family" has been adopted to designate the whole of the offspring of a given father and mother tree.

[2] The following seedling families obtained by self-pollination deserve special mention: Bgn. 105—01, Bgn. 119—2, Bgn. 202; good families resulting from cross-pollination are: Bgn. 105—04 × 83—03, Bgn. 300 × 105—04, and SA 113 × 129. In these last designations the sign × means "pollinated by". Thus SA 113 × 129 indicates a family which is the product of SA 113 as mother tree and SA 129 as father tree.

have devoted attention. The institute at Bangelan has always regarded it as one of its most significant tasks to import new species and varieties from other countries. This work was started as early as 1905 by Dr. P. J. S. Cramer, and it has been done so successfully that at present this station possesses a collection of different species of coffee which is quite unique.

Some of the most promising of these imported species have been used for inter-crossing and selection. A few of them may be mentioned here.

Coffea congensis is the small-leaved species which possesses the great virtue of being practically immune to the coffee-leaf disease but yields very poorly. It has produced hybrids by pollination by Uganda coffee, a variety of *robusta*. These hybrids have been given the name of *conuga*. Different conuga strains, descendants of selected mother trees, are at present under observation and several of the clones and seedling families seem quite promising. The *quillou* variety of *robusta* is very productive on some soils. *Quillou* Bgn. 121 may be mentioned as one of the superior strains. At Sumber Assin some good strains of *C. canephora* have been obtained. This species is closely allied to *robusta*. The newly imported and little known *kapakata* coffee has also been used for inter-crossing.

In 1920 the Besuki Experimental Station took up the selection of Arabian coffee. What the scientists hope to achieve is the development of a pure *arabica* strain, more or less resistant to leaf disease and suitable for cultivation in regions where at present this is impossible, but the ideal they are striving for is still far from being realized. For, as a matter of fact, no tree with notably less than average liability to leaf disease has yet been found. Another subject scientists have in view is to obtain a hybrid between Arabian coffee and some resistant species which shall combine some of the fine qualities of the Arabian with a certain resistance against leaf disease. At Sumber Assin hybrids were obtained by pollination of *arabica* coffee with *C. laurentii*, and one of these, Arla 1, seems promising. Hybrids have also been produced by crossing *C. arabica* and *C. congensis*.

Twenty years is a short time for selection work, especially when we are dealing with a perennial crop, and we have not yet come to the point where we can claim that the Experimental Stations have ready to hand clones and seedling families to suit the exact needs of any and every estate that may apply for advice and assistance. But for all that there is reason to look with satisfaction on the work so far accomplished. For thanks to the arduous and expert labours of different scientists there are a number of excellent clones and seedling families available for the planters to use as a basis for the individual experiments which each must inevitably make for himself on his own particular estate in order to discover which of various promising strains is best suited to the special conditions he has to offer. Planters have come to realize this and one may say that it is now the general custom with them to avail themselves of the selected material offered by the various institutions mentioned in the course of this article.

Reviews

HEIL-UND GIFTPFLANZEN DER EINGEBORENEN VON TANGANYIKA, Peter R. O. Bally, *Repert spec. nov. veg. veget., Beihefte, Bd.* 102, 1938. Pages 87 with 19 plates. Price RM 20, paper covers.

After a critical introduction the work describes 345 medical and poisonous plants used by Tanganyika natives. Three indices arranged to show the medicinal applications, the botanical and native names follow. The latter lists 126 Chagga, 80 Masai, 78 Nyamwesi, 60 Sukuma, 52 Shambaa drugs and a few, usually less than 20, from each of a number of other tribes.

It is obviously impossible to review the whole of the information presented, but taking a few drugs at random it appears that due care has not always been exercised to present information accurately or to acknowledge its source. While the latter is probably due to oversight, lack of full references detracts from the value of the work. The record of the use of *Landolphia parvifolia* as an ingredient of arrow poison is ascribed to Emin Pasha, but this identification was only recently suggested for the native name in Emin Pasha's description and must be regarded with doubt. The Dar es Salaam laboratory service is reported as describing *Phytolacca dodecandra* as a fish poison. Actually it was described to Bally as in widespread use to accomplish homicide (compare Medical Department Annual Report 1935, page 113). *Randia vestita* is described as employed by a qualified doctor for gonorrhoea with success but the references quoted show no authority for this statement. On the other hand some description of the unsuccessful trial of *Pedalium murex* on 164 patients afflicted with gonorrhoea, at the Sewa Hadji Hospital, might well have been included (Amani Records 1903–16). A more standard spelling might have been adopted in describing native names (cf. Greenway's "Swahili Dictionary of Plant Names").

In most descriptions a note is made as to whether alkaloids are present in the drug. This information could be supplemented by a reference to the active principles present where these are known and descriptions of the poisonous drugs might well include a description of such actual cases of poisoning as have been reported within the territory (cf. Medical Department Annual Report). The work contains no reference to the position of the native medicine man in the tribe or to the medicine guilds, but presumably Bally does not regard his work as a contribution to ethnography so much as an appeal for the application of African drugs in European medical practice. This is not a new subject except in so far as Tanganyika is concerned and it is doubtful whether work elsewhere on the subject has produced results comparable with the labour expended. In recent years attention has been drawn away from this subect by the spectacular advances made in chemo-therapeutic studies.

Some material of possible economic value has been noted in the present work. The presence of Embelic acid in the Mysinaceae (one species contain 6.4 per cent) and the occurrence of rotenone and other related bodies in *Mundulea suberosa* are examples. The latter formed part of Worseley's extensive investigations into the insecticidal value of local fish poisons. From the description published by Bally, *Catha edulis* may also be worthly of further investigation. *Strophanthus Eminii* which is not described in the work, contains a glucoside that differs from the official glucoside of the

B.P., but with modern methods of physiological assay the seeds of this plant may find a market in Europe. Anyone interested in this possibility could refer to British and American work on Tanganyika seed. At present this seed is employed by the dwarf Tindiga tribe in the preparation of their arrow poison.

Bally's work forms the most extensive description of the native drugs of this Territory hitherto published. It contains much new material and provides a useful cross-section of the drugs of the natives of Northern Tanganyika. But the price of the work is high and may be compared with Dalziel's study of the useful plants of West Tropical Africa. Dr. Dalziel, who was formerly in the West African Medical Service and holds in addition scientific and botanical qualifications, has presented a 612-page book at the very moderate price of Sh. 18. Such a book as Dalziel's may reveal new useful drugs, but more than this it performs an invaluable service to the administrator, official and trader working within the Colony. Bally's book falls far short of this standard but can be recommended to those who wish to make a critical study of the drugs of the natives of Tanganyika.

W. D. R.

Dairying in India

The short-horned Zebu is the hardier and therefore the more common of the two types of native cattle found in East Africa. It came from Asia and still resembles closely its relatives in India to-day. Various are the views held in East Africa as to the value of this type of animal to its European or native owner, and as to its economic status; so there must be many readers of this Journal who would like to know more about the part it plays in a country where it has exercised great influence for many centuries. A great deal of this information is packed into a "Report on the Development of the Cattle and Dairy Industries of India" (Sh. 2/50) by Dr. Norman C. Wright, and published by the Manager of Publications, Delhi.

Dr. Wright is the Director of the Hannah Dairy Research Institute, Scotland, and he was asked by the Government of India for advice as to the lines to be followed for the improvement of the dairy industry and the advancement of dairy science. To this end he appears to have spent five strenuous months in India, and to have written a report of much interest and value.

We hear much about over-stocking in Kenya and Tanganyika, each with its five million or so cattle. What then is the state of India with a cattle population estimated at 215 millions—nearly one-third of the world's cattle population? The same country is not without goats and sheep as well, and there are 15 million *she*-buffaloes, so one feels that if India can support these together with 350 millions of people, there is a lot that we can learn from that country.

But according to Dr. Wright there is much that India, too, needs to learn. The total output of milk may be more than 6,000 million gallons per annum, but this only allows a consumption of 7 oz. to 8 oz. per head per day, whereas not less than 30 oz. should be consumed if milk is to take its right place in a national dietary—in Great Britain the consumption is 39 oz., a great improvement on what it used to be, but still far short of the New Zealand figure of 56 oz.

Of course only a fraction of the milk consumed in any country is in the form of liquid milk, and in India this fraction is less than one-third. According to the report, 52.7 per cent of the total milk production is utilized as ghee, and much

interesting information is given on methods of manufacture. Reference is made to the new method evolved by French in Tanganyika Territory of making ghee direct from cream, and it is stated that a disadvantage of this method at present is that the by-product from this method of manufacture is separated milk and not buttermilk, which is preferred as a beverage by the Indian villager.

Very little indeed of India's milk is consumed as butter, cream or cheese, but 11 per cent is utilized in forms little known to Europeans, namely as *khoa* and *daki*. The former is milk concentrated by heat into semi-solid form, and is used mainly for making sweetmeats; the latter is milk soured by inoculation with a lactic acid starter, and is a popular food. There are various other milk products of less importance than the ones just mentioned.

Important as the milk and milk products are, and in spite of the fact that India is the largest exporter of hides in the British Empire, it is in the relation of cattle to the agricultural economy of the country that their unique value becomes apparent. Cattle labour represents probably the most important contribution of live stock to Indian agriculture, and a second indirect source of income attributable to cattle is their contribution to the fertility of the land. Dr. Wright pleads for better mixed farming; for "the dovetailing of the arable and animal husbandries into one mixed-farming system". He quotes an authority who says "it is evident that the cattle problem dominates the whole situation". If this be true for India, it should also be true for East Africa where most signally the native has failed to adopt satisfactory mixed-farming methods; and no agricultural problem here is more urgent than that of how to persuade the average native to utilize his stock correctly and not merely exploit the land for the little that he derives from them.

Cattle improvement is discussed at some length, and concerning breeding the wise conclusion is reached that "however valuable cross-breeding may be in herds that are under expert control, the general adoption of a policy of cross-breeding to improve the yields of country stock would be fatal to the development of sound dairying in India". The pages dealing with feeding are less satisfactory than most of the others. Recent work at Mpwapwa does not support the contention that Indian cattle have characters, not possessed by those of European breeds, which enable them to make more efficient use of their food. Also, the information now available concerning the composition and digestibility of East African feeeding stuffs could probably be applied directly to the rationing of Indian cattle.

The later chapters setting forth recommendations for the future development of research, education and advisory services in connexion with dairying and cattle improvement are of more interest to specialists than to the ordinary agriculturalist, but the following conclusion has the support of East African procedure: "It is strongly recommended that, in the interests of both efficiency and economy, live stock improvement and veterinary work should be unified under a single department of animal husbandry".

No account of dairying in India can omit reference to the buffalo, and the report under review points out that nearly 45 per cent of the milk of India comes from buffaloes. Readers may wonder why buffaloes are not used in East Africa. Some years ago buffaloes were brought from India to Dar es Salaam for the purposes of being tried as dairy animals,

and of being mated with the African buffalo. Both experiments were a failure. It was found that the animals did very well if protected from trypanosomiasis and East Coast fever, and if fed well; but it was also found that the areas where these three conditions could be fulfilled economically were strictly limited and essentially ones where European breeds of dairy cattle could also be expected to thrive and to yield better returns. An African buffalo cow mated with an Indian buffalo bull failed to conceive, and it is probable that the two species cannot interbreed.

All who are concerned with dairying or cattle management in tropical countries are advised to study this report.

H. E. H.

EROSION AND SOIL CONSERVATION, *by* G. V. Jacks and R. O. Whyte. Joint publication of the Imperial Bureau of Soil Science (Technical Communication No. 36) and the Imperial Bureau of Pastures and Forage Crops (Bulletin No. 25, Herbage Publication Series).

This important publication is an extensive survey of the literature on erosion and soil conservation, supplemented by detailed memoranda from official correspondents of the Bureaux in all the countries most concerned. It reveals the little so far done to cope with a situation that, it must be admitted, is without parallel in history. The book (206 pages of close reading) is arranged geographically. It starts with the Mediterranean region referring, among much else, to the highly erodible Pliocene clays of Italy, the study of which first began in 1771, the goat problem of Cyprus, the reconstruction of Turkish agriculture and the irreparable damage to hill country in Palestine. One gets suggestions of the fate of civilizations hanging on the proper use of soil.

In the Soviet Union, where erosion is said to be fairly extensive and increasing, the line of attack on the problem is the study of the structural stability of soil particles, soil deterioration under cultivation and, in connexion with "spent lands", the nutrients lost and the type of manuring required to restore fertility. These lands are obviously not completely lost.

In India it is the usual story of deforestation, cultivation on steep slopes, burning and over-grazing. The difficulties in the way of effective conservation are often great and parts of India are said to present a picture of man-made desolation without parallel except perhaps in China.

Ceylon, a pioneer country in recognizing the significance and consequences of erosion, is next treated. Emphasis is laid upon the importance of cover crops under rubber, coco-nuts and tea (there is some difficulty in finding a suitable one for such a specialized crop) and a summary of the legislation now in force is given. For example, in connexion with alienated Crown land, "if the Government Agent considers any works are necessary in order to prevent surface erosion of the soil, the owner shall at his own expense carry out such work to the satisfaction of the Government Agent" and in a "Land Order" for the guidance of officers issuing grants of land "the tops and sometimes the whole of steep forest-clad hills should be reserved to preserve the run-off and to prevent the erosion of soil".

British Malaya, Netherlands East Indies, Philippine Islands, Siam, China and Japan are next mentioned. The deplorable situation in China is well known. It

should be noted that the 2,500 million tons of soil which the Yellow River is computed to transport every year is more than the total quantity carried in the same period by all the rivers in the United States of America, where active conservation measures are in train. In Japan, where erosion-control estimates have for many years formed an important item in the national budget, erosion is effectively held in check regardless of cost, the alternative being almost immediate national disaster.

After a brief reference to the French Overseas Possessions we come to South Africa with its veld management and ecological research, and subsidized dam-building across gullies (a somewhat ineffective scheme, for attention has been devoted more to damming than to general erosion control). Perhaps with a more balanced outlook from having read so far, we reach via the Rhodesias the East African territories. The brighter spots of the Tanganyika section are the peasant-holdings scheme, the research and demonstration work at Lyamungu and Mpwapwa and the fact that great areas are being saved from deterioration while the tsetse fly precludes unregulated human occupation. At the same time the value of the propaganda and education being carried out must not be overlooked. The points that strike the reviewer most in the next chapter on Kenya are: the serious position in certain native reserves; the statement that there are certain parts of Kenya and Uganda where the total rainfall is likely to be affected by changes in vegetation cover not only appreciably but perhaps enormously; the spread of the Turkana desert at the rate of six to seven miles per year; and the suggested counter to it by attempting to increase the area of instability rains around Lake Victoria by planting a large forest belt about 100 miles long and several miles wide. Other points are the start made on the over-stocking problem by the establishment of a canning factory at Athi River and the proposal to carry out, if funds are available, a complete land utilization and conservation demonstration on 100,000 acres at Matungulu. In conclusion the Director of Agriculture is quoted: "It is impossible to avoid the conclusion that a task of this magnitude must be a matter for the co-operation of all Government departments and that the final responsibility for directing the many lines of attack on a vast social problem, and providing means for the executive departments to carry out their parts in the co-ordinated plan, must rest with the administration of the Colony".

In the Uganda section one reads of the expansion of cattle-keeping and crop-production and of the introduction of the plough, all to some extent to the detriment of the soil. One gets the impression, however, that the experiment stations are closely in touch with agricultural developments. Desiccation of the Karamoja watershed—which acts as a buffer to the Turkana desert—is reported to have occurred to a noticeable extent since its denudation. One notes in passing points in favour of annual burning, such as the quick reversion to bush of unburnt grazing areas and the destruction of pests. Nyasaland appears well to the fore in its interest in soil erosion but "it is apparent that no time should be lost in determining a policy of soil conservation". And so we go on via British Somaliland, Nigeria, Gold Coast and Sierra Leone to America, where much can be learnt and, if you will, a moral drawn.

It can be said that until very recently American agriculture was of the "colonial" type, cropping the land to exhaustion and moving on. Now, as was inevitable, the limit of expansion has been reached

and with it has come a combination of evils directly the result of such a short-sighted policy of land utilization. What now alarms America is the blowing away of Prairie soils in spectacular clouds of dust, the disastrous flooding of rivers and the silting up of costly irrigation reservoirs at a rate that will render them useless in a decade or so. From a diagram showing the extent of erosion in 1934 one can learn that 109 million acres of land have been practically destroyed for further tillage, 170 million acres have lost three-quarters of their top-soil, 791 million acres have lost a quarter to three-quarters, while only 578 million acres, less than a third of the country and including much not adapted to agriculture, have suffered little or no erosion. " 'Conservation' in America now involves the preservation or rational utilization, with the needs of posterity in mind, of agricultural and pastoral land, of forests, of minerals and oil, of industrial products, of wild animals, of recreational resources (national parks), and finally of man himself".

The functions of the sub-division of soil conservation are research into the problems of soil erosion and its control and the propagation of erosion control practices by practical demonstration. It maintains erosion control experiment stations in the major agricultural regions; operates a network of demonstration areas extending into forty-three States; maintains a series of nurseries for the production and propagation of erosion control plants; and carries out survey work relating to the extent and nature of erosion, the effect of erosion on reservoir silting and similar problems. On the research side interesting work on the definition of soil erodibility is being done, while at the experiment stations the regional problem is tackled in its entirety and in a practical way by a team of specialists, including soil technologists, agronomists, engineers and foresters. Further, the problem is brought right home to the farmer by a co-operative scheme in which Government contracts to survey the farm, advise technically on erosion control and supervise construction of necessary works while the farmer contracts to maintain these and follow the recommended agricultural practices for a period of five years. Labour is drawn from the Civilian Conservation Corps, an organization of unemployed youth. The farmer is generally soon enthusiastically in favour of conservation practices.

Canada, where the main problem is wind erosion, is dealt with at some length. It will surprise those who have always regarded the prairies as one of the most fertile wheat-producing areas of the world to learn that there is in existence in Canada an act called the Prairie Farm Rehabilitation Act. The West Indies, including Jamaica, Puerto Rico, Windward Islands, Leeward Islands and Trinidad, Australia and Fiji, complete the book's itinerary. It is undoubtedly a valuable book both for reference and as a basis for enlightened opinion on this complex subject.

W. E. C.

Bulletins on Seed Production of Herbage and Forage Plants.

A series of six Bulletins has been published by the Imperial Bureau of Herbage Plants, Aberystwyth, on questions relating to the production of seed of herbage and forage plants. In view of the number of bred and selected strains now being reproduced for seed in different parts of the world, the agronomical technique to be used in the production

of seed is an important question at the present time. The Bulletins are intended for the use of agricultural research workers, advisers, seed producers and seedsmen, and will also be of value to practical farmers, who will find information on many points which are important in the production of good crops of clean seed of grasses, clovers and other forage plants under a wide range of climatic and other conditions.

The chief Bulletins in the group are Nos. 19 (5/-), 22 (5/-), and 23 (5/-). Bulletin 19 describes the technique used in producing seed of a number of grasses in all parts of the world, while Bulletin 23 is a companion issue dealing with legume (clovers, lucerne, etc.) seed production. Bulletin 22, by Gwilym Evans, Officer in Charge of Seed Production on the Welsh Plant Breeding Station, contains a description of the technique which has been evolved for producing seed of the various hay and pasture strains bred at the station. Special consideration is given to the dates and rates of sowing, isolation, manures and fertilizers, harvesting, seed conditioning and storing. The Bulletin contains a brief statement of the new scheme for marketing seed of these bred strains, in which collaboration will be assured between the station on the one hand and the seed trade and growers' association on the other; a complete scheme of inspection and certification will be incorporated. The final section of Bulletin 22 is a list of the bred strains released by the Welsh Plant Breeding Station, with a brief statement of the characteristics of each.

The other Bulletins on the subject of seed production are No. 20 (2/6) on insects and other pests injurious to the production of seed in herbage and forage crops, by H. F. Barnes of the Entomology Department, Rothamsted Experimental Station, Bulletin 21 (1/-) on the influence of climatic conditions on type composition, by N. Sylvén of the Plant Breeding Station, Svalöf, Sweden, and No. 24 (2/-) on the collection of native grass seed in the Great Plains, U.S.A., by F. J. Crider and M. M. Hoover. This last publication will be of particular interest to persons in the more arid grassland countries, where erosion is a problem, as it contains illustrations of the typical grasses of the Great Plains, which are being reproduced in connexion with the soil conservation programme.

Copies of these Bulletins are obtainable from the Chief Officer, Imperial Bureau of Herbage Plants, Aberystwyth.